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Acknowledgements

Project Team

Kyle Barbehenn, Biologist, HED
Dennis Carluzzo, Attorney, OGC
Douglas Chambers, Biologist, BFSD
David Eberly, Project Manager, SPRD
Thomas Edwards, Pharmacologist, HED
Linda Garczynski, Writer/Editor, SPRD
Andrew Gordon, Attorney, OGC
Roger Holtorf, Economist, BFSD
William Jacobs, Biologist, RD
Daniel Peacock, Biologist, RD

EPA Pesticide Chemical Review Committee (PCRC)

Charles Gregg, OWWM
Richard Hill, OPTS
Allen Jennings, OPM
Donna Kuroda, ORD
Lois Jacobs, OE
Ray Smith, OANR
Marcia Williams, Chairperson, SPRD, OPP
Michael Winer, OGC

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I. Introduction

A. Background

1. The RPAR Process

Through the Federal Insecticide, Fungicide and Rodenticide Act as Amended (FIFRA), the United States Environmental Protection Agency (EPA) has the authority for regulating the use of pesticides. This authority includes the registration, reregistration, and classification of pesticides. The process for administering this authority provides for the identification of pesticides that appear to cause unreasonable adverse effects on human health and the environment.

Under this process, each pesticide and its metabolites or degradation products is evaluated for its potential to meet or exceed any of certain risk criteria. The three general risk criteria (acute toxicity, chronic toxicity, and lack of emergency treatment) are described in 40 CFR 162.11. If the Agency's evaluation of a pesticide, from available information, indicates that the potential for unreasonable adverse effects exists, a notice of rebuttable presumption against registration and continued registration (RPAR) is published in the Federal Register. The notice explains the reasons for the presumption(s) and provides an opportunity for registrants, applicants, and other interested parties to rebut or support the presumption.

EPA examines the rebuttals and the supporting evidence to determine if the original presumption(s) are still valid. If the rebuttal analysis results in a conclusion that one or more of the criteria is met or exceeded, a complete risk assessment is performed. This assessment documents the risks associated with the use(s) of the pesticide, methods for reducing or eliminating these risks, and the risks associated with the substitution of alternatives. A benefit analysis of the use(s) of the pesticide is also performed. The principal concern in the benefit analysis is an assessment of the economic impacts on pesticide users and on the consumers of the user's products. The benefit analysis identifies the major and minor uses of the pesticide and the registered alternative products. A determination is made of the change in costs for treatment with available substitute products. The regulatory impact on use productivity, in terms of yield per acre or total output, is assessed. Also, the impact on major agricultural commodities and retail food prices, should the uses of the pesticide be cancelled, is assessed.

A comparison of the risks and benefits of each use is made and available regulatory options are developed. The impact on the risks and benefits is evaluated for each regulatory option. The final Agency decision is based upon achieving the goal of a pesticide performing its intended function without causing unreasonable adverse effects on the environment. Thus, the Agency attempts to determine the regulatory position at which benefits exceed risks and at which further risk reduction is not appropriate given the corresponding benefit reduction which could occur.

2. Strychnine RPAR

The RPAR notice for strychnine was published in the Federal Register of December 1, 1976 (41 FR 52810). The presumption was against all outdoor above-ground uses of strychnine. Three other actions by the Federal government involving strychnine should be noted. In March of 1972, Executive Order 11643 was issued. This order prohibited the use of all toxicants, including strychnine, for control of predators on Federal lands or in Federal programs. In the same year, EPA cancelled the registrations of thallium sulfate, cyanide, strychnine, and compound 1080 for predator control. Additionally, in February 1978, EPA restricted use of several pesticides, including strychnine formulations with concentrations greater than 0.5 percent, for use only by certified applicators (43 FR 5791). The criteria influencing the restriction for strychnine were acute oral toxicity, hazards to nontarget species, and use and accident history.

The criteria that were determined to have been met or exceeded for the outdoor above-ground uses of strychnine are: 1) acute toxicity to mammals and birds and 2) significant reduction in populations of nontarget organisms and fatalities to members of endangered species. The reasons for the determination were explained in detail in the RPAR notice and accompanying Position Document 1 (Appendix A). The following paragraphs summarize the information available at the time the PD1 was issued.

The acute toxicity criterion was based on a determination that nontarget mammals and birds are likely to consume lethal quantities of strychnine bait. A lethal quantity could be consumed directly by eating the bait, or indirectly by eating a strychnine-poisoned organism. Strychnine LD_{50} values were not, and are not, available for many of the suspected nontarget species. Risk to such nontarget species was based on available LD_{50} values of target and nontarget species of the same genus as those for which LD_{50} values were unavailable.

The reasoning that the significant reduction in nontarget organism populations criterion was met is based on three items. First, the acute oral toxicity data suggest a risk to nontarget species through direct ingestion of strychnine-treated bait can reasonably be expected. The second factor was the deaths of eight Canada geese in 1968. Their deaths were attributed to the ingestion of strychnine-treated gopher bait (Howell and Wishert, 1969). The third item was a draft report on a study assessing the field hazards of 0.5 percent strychnine ground squirrel bait (Hegdal, 1976). The preliminary conclusion was that several thousand birds could have been killed as a result of the treatment with strychnine of 9,000 acres for ground squirrel control.

The criterion for endangered species was based on a laboratory study that demonstrated a hazard to the endangered San Joaquin kit fox from secondary poisoning. In this study, a kangaroo rat was killed with a quantity of strychnine that could be consumed by the rat by ingesting strychnine treated grain bait. A desert kit fox, a subspecies of kit fox related to the San Joaquin kit fox, was fatally poisoned by eating the kangaroo rat.

B. Strychnine

1. Physical and Chemical Properties

Strychnine is a highly toxic product extracted from the seeds of an Asiatic tree (*Strychnos nux-vomica*). The crude extract may be purified to form strychnine alkaloid, strychnine sulfate, or other strychnine salts. Strychnine alkaloid is a colorless or white solid which is practically insoluble in water, alcohol, and ether, but is slightly soluble in chloroform and benzene. Strychnine sulfate is soluble in water and alcohol and insoluble in ether. Strychnine compounds are stable in the environment but are either metabolized or excreted by animals.

2. Production

The entire U.S. strychnine supply is imported, mainly as strychnine or its salts. A small quantity of the seed is imported for processing in the United States. In 1978, India supplied 91 percent and Israel nine percent of the approximately 14,500 pounds of the processed strychnine imported by the United States. The bait is then formulated in the United States for domestic use. In previous years, France, United Kingdom, West Germany, Canada, and Laos have also exported strychnine to the United States (*Pesticide Review*, USDA, 1978).

3. RPAR Uses

Currently 116 strychnine products are federally registered for control of major rodent pests (including ground squirrel, prairie dogs, house mice, and field mice of the genus *Microtus*); minor rodent pests (including chipmunks, woodchucks, kangaroo rats, cotton rats, porcupines, and field mice of the genus *Peromyscus*); lagomorphs (jackrabbits); and birds (pigeons and house sparrows).

In addition, 277 products have state registrations. Certain states have issued their own state registrations for strychnine uses covered by Federal registrations. Also, specific states have issued their own registrations for uses *not* covered by Federal registrations. For example, California has registered strychnine for use against marmots, rabbits, blackbirds, cowbirds, horned larks, house finches, white-crowned sparrows, and golden-crowned sparrows. Wyoming has registered strychnine for mountain beavers, opposums, marmots, and magpies. Nevada has registered strychnine for magpies, and Oregon has registered strychnine for rabbits. See Table I-1 for a summary of the registered uses of strychnine.

For the purposes of analysis, the uses of strychnine have been grouped into five site/pest categories. In many cases, these sites are not specified on labels, and the analysis reflects historical use.

Table 1-1.

Strychnine, Federal-State Registrations

		Major use sites				
		Agricultural		Nonagricultural		
Pest	Registration	Cash crops, livestock	Range, pasture, fallow	Forests, reforestation areas, tree plantations	Buildings, warehouses and homes 1/	Non-Crop 2/
A. Birds						
o Pigeons	Fed.	Ca.			X	
o House sparrows	Fed.	Ca.			X	
o Blackbirds	State (Ca.)	X				
o Cowbirds	State (Ca.)	X				
o Horned larks	State (Ca.)	X				
o Starlings	State (Ca.)	X				
o House finches	State (Ca.)	X				
o White and golden crowned sparrow	State (Ca.)	X				
o Magpies	State (Nv. & Wy.)	X				
o Meadowlark	State (Ca.)	X				
o Crows	State (Ca.)	X				
o Bluejays	State (Ca.)	X				

1/ Includes adjacent areas.
2/ Includes golf courses, parks, cemeteries, athletic fields, ditch banks, canals and levees.

Source: Federal Registration: Site/pest listing from EPA registration files, 1980
State Registration: State Agencies: California Department of Food and Agriculture
Nevada Department of Agriculture
Oregon Department of Agriculture
Wyoming Department of Agriculture

Table I-1.

Strychnine, Federal-State Registrations

Pest	Regis-tration	Major use sites				
		Agricultural		Nonagricultural		
		Cash crops, livestock	Range, pasture, fallow	Forests, reforestation areas, tree plantations	Buildings, warehouses and homes 1/	Non-Crop 2/
B. Mammals						
o House mice	Fed.				X	
o Ground squirrels	Fed.	X	X		X	X
o Prairie dogs	Fed.	X	X			X
o Jackrabbits	Fed.	X	X			X
o Deer mice	Fed.	X	X			X
o Meadow mice	Fed.	X	X			X
o Kangaroo rats	Fed.	X	X			X
o Cotton rats	Fed.	X	X			X
o Chipmunks	Fed.	X	X			X
o Porcupines	Fed.			X		
o Marmots/ Woodchucks	Fed.	X	X			X
o Rabbits	State (Ca. & Or.)	X		Or.		
o Mountain beavers	State (Wy.)					X
o Opossums	State (Wy.)					X

1/ Includes adjacent areas.
2/ Includes golf courses, parks, cemeteries, athletic fields, ditch banks, canals and levees.

Source: Federal Registration: Site/pest listing from EPA registration files, 1980
State Registration: State Agencies: California Department of Food and Agriculture
Nevada Department of Agriculture
Oregon Department of Agriculture
Wyoming Department of Agriculture

a. Rangeland/pasture rodents:

sites - rangeland and pastures

pests - ground squirrels, prairie dogs, jackrabbits, deer mice, meadow mice, kangaroo rats, cotton rats, chipmunks, and marmots/woodchucks.

b. Cropland rodents and lagomorphs:

sites - field crops such as grains and forages and horticultural crops such as nuts, fruits, and vegetables

pests - ground squirrels, prairie dogs, meadow mice, deer mice, chipmunks, rabbits, cotton rats, kangaroo rats, jackrabbits, and marmots/woodchucks

c. Nonagricultural rodents and lagomorphs:

sites - grain elevators, other crop storage areas and facilities, commercial buildings and warehouses, open dumps, farmsteads, urban dwellings, ditch banks, levees, dikes, canals, earthen dams, golf courses, parks, cemeteries, athletic fields, recreational areas, airport turf runways, military bases, tree nurseries, tree plantations and reforestation areas.

pests - rabbits, jackrabbits, chipmunks, marmots/woodchucks, ground squirrels, prairie dogs, kangaroo rats, cotton rats, deer mice, meadow mice, house mice, porcupines, mountain beavers, and opossums

d. Cropland Birds:

sites - grape, cherry, lettuce, sugarbeet, rice, tomatoe, plum, melon, strawberry, vegetable crop, soft fruit, and small grain areas.

pests - house finches (linnets), horned larks, meadow larks, starlings, cowbirds, crows, magpies, blackbirds, pigeons (rock doves), house sparrows (English sparrows), and crowned sparrows.

e. Nonagricultural birds:

sites - structures and roosting sites
pests - pigeons and house (or English) sparrows

4. Estimated Usage

Approximately one-half million pounds of strychnine bait were used annually for above-ground control of rodents, lagomorphs, and birds during 1977-1978. The majority of the bait usage was in 17 western states for controlling ground squirrels and prairie dogs. Ninety percent of the bait was used for rodent control, the remaining 10 percent for birds. Rangeland/pasture use and cropland use were approximately equal and accounted for 91 percent of the strychnine bait. The other nine percent was used on nonagricultural sites. The percentage of use for each site/pest combination is shown in Table I-2.

Table I-2

Percentage of Use by Site/Pest Combination

PEST	SITE Rangeland/Pasture	Cropland	Nonagriculture	Total
Prairie Dogs	17.6%	2.8%		20.4%
Ground Squirrels	27.6%	38.4%		66.0%
Other Rodents and Lagomorphs[1/]	0.4%	0.9%		1.3%
All Rodents and Lagomorphs			2.4%	2.4%
Birds		3.6%	6.3%	9.9%
Total	45.6%	45.7%	8.7%	100.0%

[1/] Other than prairie dogs and ground squirrels.

II. Rebuttal Analysis

A. Background

Registrants and other interested parties were offered an opportunity to review the data upon which the RPAR against strychnine was based and to submit information to rebut the presumptions. Respondents could rebut the presumption by showing that the Agency's initial determination of risk was in error or by showing that common use patterns and actual exposure indicate that use of the pesticide is not likely to result in any significant adverse effects (40 CFR 162.11(a)(4)(i),(ii),(iii)).

Registrants and other interested persons were also offered the opportunity to submit evidence as to whether the economic, social, and environmental benefits of continuing to use this pesticide outweigh the risks of its use (162.11(a)(5)(iii)). These comments are considered in the development of Section IV of this document.

The Agency received 100 rebuttal submissions in response to the RPAR on strychnine. No scientific data were submitted to support the majority of the comments received. Moreover, the little scientific data submitted were either insufficient or contained inadequate test methods to support the position taken. Significant rebuttal comments and the Agency's responses are presented in this Section. The complete rebuttal analysis is contained in Appendix C.

B. Risk Criterion - Acute Toxicity to Birds and Mammals

1. LD_{50} Range

A number of respondents said that the Agency erred in PD 1 by stating that there is a narrow range of LD_{50} values for strychnine among birds and mammals tested (30000/7: # 1B, 1C, 1D, 74, 82, 89, 94).

Admittedly, the LD_{50} values in Table III-1 (page 20) show a range from 0.7 mg/kg (coyote) to 112 mg/kg (California Quail). The specific values or the range of toxicity values are not the only factors to consider in evaluating the hazard to nontarget species. The similarities between target and nontarget species in terms of exposure to the bait and feeding behavior must also be considered.

Of the 40 species for which toxicity data were available, however, all but four (nutria, California quail, sage grouse, turkey) had LD_{50}'s approximately equal to or less than that of major target species (ground squirrels and pigeons). Thus, baits formulated to control ground squirrels and pigeons are potentially hazardous to most other species. From this consideration alone, the presumption is not rebutted for this risk criterion.

2. Exposure to bait

Many respondents maintained that relative toxicity alone was inadequate to presume that risks to wildlife exist. Proper selection of baits (form, size, color) and method of application coupled with the behavior and ecology of target and nontarget species greatly influence the results (30000/7: # 1B, 1C, 1D, 39, 74, 81, 82, 91, 96). The use of dyes to deter birds from feeding on baits used in rodent control was emphasized in these rebuttals.

The Agency agrees in principle that there are several factors that determine the degree of risk to any particular local population from a particular treatment. Whether or not, for instance, the routine use of dyes in surface baiting for rodents can be relied on to substantially reduce risks to birds is a germane question, since it provides a potential method for reducing risk, and one that is easily enforceable.

The Agency has reviewed all documents submitted to support the contention that dyes are effective in protecting birds (Kalmbach, 1943, Kalmbach and Welch, 1946, Howard, 1950, Davidson, 1962, Clark, 1975). The accumulated observations suggest that the use of certain dyes may prevent some birds from taking lethal doses of treated grain. There is nothing in these studies, however, that could enable predictions of the general degree of risk reduction in the field or to understand those factors that influence the success of risk reduction in any particular operation. Furthermore, the general enthusiasm for the usefulness of dyes as a feeding deterrent is not without some qualifications. Schaefer (1978) stated that dyes provide only a short term deterrent and that their effect is soon lost unless it is reinforced by ingestion of doses of bait that cause illness. Hegdal et al. (1979) noted that the bright yellow dye applied to a compound 1080 bait faded noticeably after three to four days of exposure to the sun and that exposed surfaces of the dyed oats were virtually indistinguishable from undyed oats after two weeks. In conclusion, the use of dyes may contribute some degree of protection to various bird species, but this has not been quantified under normal conditions of use.

Other relevant comments regarding exposure and its reduction will be considered by the Agency in assessing risks and in developing regulatory options for each use. In general, however, current levels of use do not preclude exposure to all nontarget organisms and, thus, rebuttals on the acute toxicity criterion based on exposure arguments are not valid.

3. Other Studies on Birds

Howell and Wishart's (1969) report of Canada geese killed by strychnine was used by the Agency in its presumption to illustrate that the use of strychnine can result in wildlife mortality. This report was criticized by several respondents (30000/7: # 1B, 1C, 1D, 7, 39, 82, 91) on the following grounds: that the death of eight geese is insignificant compared to the number killed by hunters; that there was no conclusive evidence that strychnine was the cause of death or that the deaths resulted from the stated use of strychnine; that there was no evidence that the bait had been properly dyed; that the surface baiting for gopher control did not follow directions for use.

All of the above arguments fail to rebut the Agency's point. The deaths of the geese illustrate the potential for causing wildlife mortality and the magnitude of this particular incident is not relevant. The laboratory analysis which indicated the presence of strychnine in the gizzards and livers of the geese strongly supports the conclusions that strychnine was the cause of death.

The dying of bait for surface application is not a requirement on federally registered labels and the application of bait around the burrows of ground squirrels and prairie dogs is a usual practice. Thus, it is reasonable to conclude that proper application of strychnine baits for certain registered uses presents a risk to geese and other susceptible species that may be feeding in the treated area.

Several respondents referred to studies that lead to the conclusion that strychnine-treated baits present little or no hazard in gallinaceous birds (30000/7: # 1B, 1C, 1D, 7, 39, 74, 81, 82, 91, 96). The inference was that risks were negligible for birds in general.

The referenced studies (Ward, et. al. 1942, Scheffer, 1922, Oman, 1923, Garlough and Keyes, 1925, and Knowles, 1937) all suffer from deficiencies in procedures that are not acceptable by current standards (Appendix B). Major weaknesses include inadequate sample sizes and exposure protocols. However, collectively, the studies suggest that strychnine baits are not highly toxic to several species of gallinaceous birds and such a result is consistent with available information on LD_{50}'s. These limited data suggest that gallinaceous bird are the least susceptible of all bird species tested and, therefore, one cannot infer a lack of acute toxic risk to birds in general.

In summary, the Agency's presumption that the use of strychnine treated baits would result in the exposure of nontarget wildlife to toxic levels of strychnine has not been rebutted either on the grounds of basic toxicity of common formulations to most species or on the absence of exposure.

C. Risk Criterion - Significant Reduction in Populations of Nontarget Species

In presuming that the above-ground use of strychnine caused significant reductions in local population, the Agency cited studies by Hegdal and Gatz (1976) and by Howell and Wishart (1967). One or both of these studies were criticized by a number of respondents (30000/7: # 1B, 1C, 1D, 7, 39, 74, 82, 91, 96).

1. Hegdal and Gatz Study

Under an Environmental Protection Agency (EPA) Interagency Agreement, The Fish and Wildlife Service (Denver Wildlife Research Center) evaluated the hazards associated with surface strychnine baiting for Richardson's ground squirrel. In south-central Wyoming (during late April and early May 1976) approximately 3650 ha (hectare)[1] (9000 acres) were treated with 0.5 percent strychnine-treated bait. Approximately one tablespoon of bait was placed (from horseback) at or near ground squirrel burrows. Application rate varied between one and two kg/ha (one to two lb/acre). Treated areas were scattered between Saratoga and Encampment, Wyoming. Effectiveness on ground squirrels varied, with some plots showing almost no effect while others indicated up to 85 percent control. An average of 3.5 dead ground squirrels/ha searched (1.4/acre) were found. Data also indicate many territorial horned larks were killed by the bait. An average of 2.5 dead horned larks/ha searched (1.0/acre) were found. In addition, after treatment, horned larks were scarce in treated areas and most marked horned larks were killed by the bait. Blackbirds, especially red-winged and Brewer's, were killed early in the season, while migrating through the area. Territorial red-winged and yellow-headed blackbirds appeared to be reduced in number. Populations of vesper sparrows and western meadowlarks were not seriously affected. Mourning doves did not arrive until early May when baiting was well underway. Nevertheless, an average of 1.1 dead doves/ha searched (0.4/acre) were found. In addition, telemetry data coupled with residue data indicate that many radio-equipped doves using treated areas were killed by the bait. Two female ducks (one mallard and one pintail) nested in treated fields and telemetry data indicated they were not affected by the treatment but one treatment-killed mallard was found. No detrimental effects on raptors and mammalian predators were detected and most active raptor nests fledged relatively high numbers of young.

Respondents argued that the bait had not been dyed, that it had been applied from horseback and therefore could not have been placed under cover as required on the label and that the application rate was higher than that on the label (but less than that reported by Hegdal and Gatz). Questions were also raised regarding the adequacy of the area sampled, the limited number of dead birds analyzed for strychnine, the lack of replication, and the ability of the Agency to draw conclusions from this study concerning risks to be expected from other uses of strychnine and other geographical areas.

While many of these comments point to difficulties inherent in the conduct of comprehensive research on wildlife risks associated with pesticide usage, they do not, either individually or collectively, constitute a rebuttal against the general presumption of risk. In the absence of valid risk measurements from other use situations, the Agency must exercise appropriate judgment in weighing available evidence and in making extrapolations.

It is important to note that the study by Hedgal and Gatz was conducted under the auspices of the Wyoming Department of Agriculture and that the poisoning operation was under the supervision of the Carbon County Weed and Pest Control District using a registered label. The only unusual aspect of the control operation was that the effects were monitored by the U.S. Fish and Wildlife Service under an agreement with the EPA. The Agency has no basis, either from comments by respondents or otherwise, for believing that the practices used, whether or not they were in precise accordance with the label directions, were not representative of widespread and commonly recognized practice.

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[1] One hectare = 10,000 square meters or 2.47 acres

The state of California does require that rodent baits be dyed but this is not a federal requirement and the formulation used in Wyoming was produced by the USDI (EPA Reg. No. 6704-58). The label is internally inconsistent in that, while it does state that all placements must be made in or under cover where a hazard to wildlife is present, directions for treating ground squirrels (and kangaroo rats) direct the user to "scatter one teaspoon of bait over a square foot of clean ground within two or three feet of the burrow entrance." Conceivably, horned larks and blackbirds are not considered as "wildlife" by many users and the spring arrival of doves after the bait had been placed might not be anticipated. Direction for treating prairie dogs, on the same label, call for the scattering of "tablespoon quantities of bait at the edge of mounds, where forage and soil meet." Thus, while it may be true that overbaiting was done in the Wyoming operation (some prairie dogs were present), and this apparent mis-use may have led to greater bird mortality than otherwise would have occured, the use of such quantities is recommended for prairie dog control and one could anticipate a hazard from this use.

While the 19.5 ha searched for dead animals may appear small (0.5 percent) in relation to the 3,650 ha treated, the effort assigned to this task had to be consistent with available resources and priorities allocated to components of the total project. The number of birds analyzed for strychnine was intentionally limited so that most carcasses would be available to assess risks to any scavengers. The failure of chemical analysis to detect strychnine in the gastrointestinal tract of some of the dead birds is an anticipated result since just-lethal doses would be totally absorbed before death. The Agency's judgment regarding the significance of the observed mortality will be described below, but it is notable that an independent consultant (Ketron, Inc., 1979), employed by the USDA to assess the results of this study, indicated that "Mortality resulting from strychnine as used for control of ground squirrels would occur just before the breeding season-that is, at the worst possible point in the population cycle. Pesticide-induced mortality of 10 to 20 percent at this time, especially if sustained from year to year, would probably have significant effects on local populations of mourning doves ..." Hegal and Gatz observed a strychnine-induced mortality of 49 percent (23 out of 47) among the doves tracked by radio-telemetry.

2. Howell and Wishart Study

The Agency agrees with rebuttal comments that the data regarding mortality to geese (Howell and Wishart, 1969) are insufficient to conclude that the incident represents a significant reduction of a local population. The observed mortality (two geese at the baited site and six falling from the air) may or may not represent the total mortality and it is impossible to know the relationship between a migrating flock and a local breeding population. The incident does indicate a potential for significant impacts from the use of strychnine.

In general, the argument that mortality in local populations is quickly compensated for by natural processes (30000/7: # 74) is not acceptable. It cannot be assumed, a priori, that all local nontarget populations are substantially less susceptible to poisoning than is the target population. If the aim is to significantly reduce the target population, it follows that some local nontarget populations will be similarly affected.

3. Rebuttals regarding other field observations

Several respondents claimed that the Agency failed to adequately demonstrate hazards to nontarget species and that few or no nontarget animals have been found dead in searches following strychnine treatments (30000/7: # 1B, 1C, 1D, 8, 8A, 44, 81, 91). Such allegations of no observable effect are difficult to evaluate. Presumably there may be conditions where the use of strychnine has not led to substantial nontarget mortality but, even where searches have been made, it is possible that the actual mortality has been underestimated for various reasons. Many of the birds (Hegdal and Gatz 1976) and mammals (Hegdal et al. 1979) found by Hegdal and his associates would have gone undetected had it not been for the use of radio telemetry. To balance the general denial of observed mortality, the Agency should note the report from Nevada (30000/7: #8) indicating that 16 dogs, 18 cats, 44 cottontails, 142 jackrabbits, 12 field mice, one badger, three hawks, 33 crows, and 24 magpies were found dead following a baiting operation of strychnine treated cabbage. Although no chemical analyses for strychnine were conducted, it would be unreasonable to assume that the observed mortality was somehow independent of the baiting operation. However, the significance of the mortality to local populations cannot be assessed from the available information.

4. Rebuttals on secondary poisoning and endangered species

The Agency relied primarily on a laboratory study by Schitosky (1973) to demonstrate that endangered species such as the kit fox, the black-footed ferret, and the California condor were at risk from indirect exposure to strychnine through the consumption of poisoned rodents. Several respondents maintained either that the laboratory demonstration could not be used to predict risks of secondary poisoning in the field or that various field observations failed to support the predication in any substantial way (30000/7: # 1B, 1C, 1D, 8, 39, 74, 81, 82, 91, 94, 96, 100).

While there are limits on the ability to quantify risks in the field from laboratory studies, the potential for risk can only be rebutted by demonstrating either that the study was invalid or that the Agency's interpretation of the study was faulty. Respondents did not demonstrate any basic flaw either in the laboratory study or in the Agency's interpretation. Some respondents (30000/7: # 8, 81, 86) have reported deaths of cats, dogs, gray foxes, coyotes and other species in close association with strychnine baiting operations for rodents. While none of this mortality was confirmed by residue analysis, it is reasonable to conclude from the basic toxicity data and the anecdotal reports that some secondary poisoning of carnivores has occurred from the use of strychnine to control rodents. Additionally, the Agency has new information on raptor mortality associated with the use of strychnine to control pigeons. These data will be presented below in the risk assessment. The risk criterion has not been rebutted by claims that secondary poisoning cannot occur in the field.

Respondents (30000/7: # 1B, 1C, 1D, 74, 82, 94) also argued either that endangered species generally were not being jeopardized by pesticides but by habitat loss; that the population of the San Joaquin kit fox was increasing; that designation of some populations as endangered species is based on a taxonomic technicality; or that no endangered species were present in many areas of use. Such arguments do not serve to rebut the criterion.

While habitat loss may be the major reason for the endangerment of some species, it does not logically follow that additional losses due to pesticides will not exacerbate the situation. The precise status of most species is difficult to establish. Claims that the number of kit foxes is increasing rests on estimates so crude that little confidence can be placed on the suggested trend. Until such time that the species may be removed from the endangered list, any losses due to pesticides are of significant concern to the Agency.

The authority for designating endangered species and their critical habitat rests with the Department of Interior, and the EPA makes appropriate responses to their determinations on the status of various populations when it can be expected that the use of a pesticide will cause mortality to individuals. Most current strychnine labels do not restrict the use of strychnine in ways that would preclude exposure to endangered species, and allegations concerning the absence of endangered species in certain locations where strychnine is likely to be used do not serve to rebut the general criterion. The Agency agrees that endangered species do not reside in many areas where the use of strychnine is desired. The feasibility of permitting use under such circumstances is considered in formulating regulatory options in Section V.

5. Miscellaneous Rebuttals

Many respondents indicated that special formulations or modes of application for certain pests reduced or eliminated exposure to nontarget species. Comments regarding bird control (30000/7: # 1B, 1C, 49, 56, 82), porcupine control (30000/7: # 50, 51, 74, 85), commensal rodent control (30000/7: # 44, 74, 96), rabbit control on crops and rangeland and certain other minor uses (30000/7: # 63, 71, 83, 89, 90, 91, 95) failed to rebut all presumptions but the appropriate details of these submissions will be discussed in the risk/benefit analysis and regulatory options (Section V). Comments regarding rabbit control in reforestation areas (30000/7: # 85) and mountain beaver control (30000/7: # 50) deal with unregistered uses. Comments on skunk control (30000/7: # 49, 94) and on the pocket gopher/mole control (30000/7: #2, 8, 48, 57, 56, 58, 62, 65, 74, 79, 91, 98) deal with uses that are not the subject of the strychnine RPAR. Comments on these latter uses, therefore, will not be discussed.

III. Risk Analysis

The risk analysis is a detailed study of the risks associated with the registered uses of the RPAR chemical. The specific risks examined are those for which the RPAR notice was issued. In the case of strychnine, the focus of the analysis is the risk to nontarget birds and mammals, including members of endangered species, from exposure to treated bait.

The approach taken is to first present the common methods of baiting for various target birds and mammals. This information will form the background for the subsequent analysis of the risks to nontarget species. Next, acute and chronic toxicity data, from laboratory and field studies, are presented. The data are for both target and nontarget organisms, and form the basis for the assessment of the risks associated with the baiting practices.

The same approach is used in analyzing the risks of the various alternatives. The alternatives examined are those that are currently registered for the same uses as strychnine.

Following the analysis of the risks of using strychnine and the alternatives, the relative risks are assessed and summarized for each use pattern.

A. Strychnine

1. Methods of Application for Target Species

a. Ground Squirrels

Strychnine is mixed into baits, usually grains such as oats or barley, but also chopped cabbage or dandelion greens. The final use strength of the baits ranges from 0.2 percent to 0.52 percent strychnine alkaloid. Either one teaspoon or one tablespoon of bait is scattered near the burrow entrance or on runways used by the ground squirrels. This is most often done in the spring during the breeding season but some labels call for repeated treatments if squirrels remain after initial treatment. Many of these labels recommend that bare ground is the best bait placement site. A few others call for placing the bait in the burrow or under brush cover if other wildlife is present. On the average, there are approximately 80 bait placements per pound of bait and a pound should treat 10-15 acres. For heavy infestation, one pound may treat only two-three acres. Oat baits may retain full strength for three days or more on the ground in the absence of rain. Approximately an 85 percent residue loss through degradation occurred in baits 10-18 days after application (Hegdal and Gatz, 1977a).

b. Prairie Dog

The concentration of the active ingredient of strychnine grain baits for control of prairie dogs vary from 0.3 percent to 0.5 percent. Two teaspoons to one tablespoon of bait is scattered near prairie dog mounds on the side away from the dirt pile. About 0.5 to 3.0 pounds of bait are used per acre in this manner. Some labels caution against use if black-footed ferrets are in the area or direct the user to place the bait under cover of brush or weeds if wildlife hazards exist.

c. Other Mammals

1) Jackrabbits

Baits consist of grains (mostly rolled barley, but oats are also used), root vegetables and fruit, or greens. The concentration of strychnine in the bait ranges from 0.28 percent to 1.5 percent for grain baits. For green baits, formulations range from one ounce of five percent strychnine on three pounds of bait (0.1 percent) to one ounce of 99.5 percent strychnine on 20 pounds of bait (0.3 percent).

A variety of methods are used for applying the bait; a heaping tablespoon of bait in mounds 10 feet apart, a half cup at locations where pre-baiting is accepted, one or two heaping tablespoons at intervals of 35 to 50 feet, or one teaspoonful where pre-baiting is accepted. Applications are made along the rabbit trails, around the perimeter of the field, along tree rows or where trails meet.

2) Kangaroo and Cotton Rats

Strychnine grain bait is formulated at concentrations of from 0.25 percent to 1.0 percent. Application rates are made by hand in amounts of one or two teaspoonfuls eight to ten feet apart.

3) Porcupines

Strychnine treated salt blocks (5.8 percent concentration) are nailed to trees, placed in porcupine dens, or placed under shelters. Also, strychnine pellets are placed in bait boxes.

d. Pigeons and House Sparrows

For pigeon control, whole corn bait with a concentration of 0.6 percent strychnine is scattered on the ground following prebaiting with untreated grain. For house sparrows, grain bait with a concentration of 0.25 percent to 0.8 percent strychnine is either scattered on the ground or placed in troughs.

e. Croplands Birds

For orchards and vineyards, troughs containing bait are placed in trees or on standards. The bait may be milo, rice, oats, corn or vegetables and the concentration of strychnine ranges from 0.25 percent to 0.90 percent. For the protection of sprouting vegetable seeds, baits may be applied on the ground between the furrows.

2. General

a. Toxicology

The toxic effect of strychnine is reported to be primarily against the nervous system. The threshold for stimulation of motor effects by external stimuli is lowered, resulting in such signs and symptoms as apparent hyperacusis (painful sensitiveness to sounds), recurrent convulsions or tetanic seizures. Slight touches or light stimuli produce exaggerated responses and often seizures (Tucker and Crabtree, 1970).

The fact that symptoms appear in many species as soon as 10 minutes after ingestion and that recovery of survivors is generally complete within a few hours implies rapid and thorough absorption of strychnine. Also implied is rapid metabolism in the animal body and/or elimination of the compound and metabolites (Tucker and Crabtree, 1970).

A compound which is rapidly absorbed in undiluted form and either produces death quickly, or rapid recovery, often displays a "feed-dilution effect." That is, a high concentration of the material, quickly ingested and absorbed, will produce toxic effects. However, if the compound is in such low concentration in feed that absorption is slowed, some of the ingested dosage may be detoxified before all is absorbed. This would effectively reduce the toxic effect (Howard and Marsh, 1973). Strychnine appears to be subject to this effect and hence there are reports of somewhat lower toxicity from baits than would be expected from single oral tests (Ward, et al., 1942). If administered slowly, repeated oral treatments may appear to produce increased tolerance of strychnine. This apparent tolerance may be the result of increasingly rapid elimination and/or metabolism.

Gross pathological examination of numerous wildlife species treated with strychnine at lethal levels revealed occasional hyperemia (excess of blood) and hemorrhaging of the gastrointestinal tract, minor endocardial hemorrhages, and massive hemorrhages in the myocardium. Very often no gross pathological change attributable to the action of strychnine occurred.

b. Acute Toxicity

Table III-1 provides a summary of acute oral toxicity values for strychnine relating to various species of mammals, amphibians, and birds.

The acute oral LD_{50} values for the species given in Table III-1 range from 0.75 mg/kg for the coyote and desert kit fox to 112 mg/kg for the California quail. Most LD_{50} values fall into the range of 1.0 to 25 mg/kg for both mammals and birds.

c. Subacute and Chronic Toxicity

While there are few reports of effects of long-term, low-level exposure to strychnine, it seems likely that rapid metabolism and/or

TABLE III-1 - ACUTE ORAL TOXICITY OF STRYCHNINE ALKALOID

SPECIES	LD_{50} mg/kg[1]	REFERENCE[2]
I. MAMMALS		
WILD RODENTS & RELATIVES		
Calif. ground squirrel	19.9 -28.0	DWRC Files/ DWRC Annual Reports
Black-tailed prairie dog	1.5	DWRC Files
Northern pocket-gopher	8.3	DWRC Files
Banner-tailed kangaroo rat	3.7	DWRC Files
Meadow vole	6.8	DWRC Files
Calif. meadow vole	22.2	DWRC Files
Norway rat (wild)	12.0	DWRC Files
White rat (male)	14.0	DWRC Files
White rat (female)	5.8	DWRC Files
Black rat	10.1	DWRC Files
Polynesian rat	6.8	DWRC Files
Black-tailed jack rabbit	4.4	DWRC Files
Nutria	27.0 - 42.0	DWRC Annual Reports/DWRC Unpublished Data

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[1] Data marked (S) if the sulfate was known to be used.

[2] DWRC indicates Denver Wildlife Research Center.

TABLE III - 1 (Continued)

SPECIES	LD_{50} mg/kg[1]	REFERENCE[2]
B. CARNIVOROUS MAMMALS		
Cat	0.75	DWRC Files
Dog	1-1.2	DWRC Files
Desert kit fox	0.75	DWRC Files
Coyote	0.7	DWRC Files
C. OTHER MAMMALS		
Man	1.0	Howard and Marsh
Hog	10.0	DWRC Files
Horse	2.0	DWRC Files
Cow	15.0	DWRC Files
Sheep	7.5	DWRC Files
Mule deer	17.0 - 24.0	Tucker and Crabtree
II. AMPHIBIANS		
Bull frog	2.21	Tucker and Crabtree
III. BIRDS		
A. WATERFOWL		
Mallard	2.9	Tucker and Crabtree
Canada goose	4.0	Tucker and Crabtree

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[1] Data marked (S) if the sulfate was known to be used.
[2] DWRC indicates Denver Wildlife Research Center.

TABLE III - 1 (continued)

SPECIES	LD_{50} mg/kg[1]	REFERENCE[2]
B. UPLAND GAME BIRDS AND RELATIVES		
Mourning dove	5.12(S)	DWRC Files
Pigeon	21.3	Tucker and Crabtree
Ring-necked pheasant	24.7	Tucker and Crabtree
Ring-necked pheasant	8.48 (S)	Tucker and Crabtree
Chukar	16.0	Tucker and Crabtree
California quail	112	Tucker, et al
Sage grouse	35-50	Ward, et al
Turkey	50	DWRC Files
Coturnix	22.6	Tucker and Crabtree
C. PASSERINES		
Robin	10.0	DWRC Files
House finch	5.6	DWRC Files
English sparrow	4.18	Tucker and Crabtree
English sparrow	4.0 - 8.0 (S)	Tucker and Crabtree
Starling	5.0(S)	Schafer
Red-winged blackbird	6.0	DWRC Annual Reports

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[1] Data marked (S) if the sulfate was known to be used.
[2] DWRC indicates Denver Wildlife Research Center

TABLE III - 1 (continued)

SPECIES	LD_{50} mg/kg[1]	REFERENCE[2]
D. RAPTORS		
Golden eagle	5.0	Tucker and Crabtree
Golden eagle	>5.0 (S)	Tucker and Crabtree

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[1] Data marked (S) if the sulfate was known to be used.
[2] DWRC indicates Denver Wildlife Research Center

elimination of this material would preclude cumulative toxic action to any marked degree. In addition, the bitter taste of strychnine and rapid onset of symptoms have been demonstrated to produce "bait-shyness" or poor reacceptance of strychnine-containing diets by many species. This phenomenon is known for sage grouse (Farm Chemicals Handbook, 1973), pheasants (Schaffer, 1973), and other species. It is conceivable that "bait-shy" animals might consume such baits after prolonged starvation. Two pheasants starved for two days died within an hour after consuming 20 and 34 grams, respectively, of a bait containing one ounce. strychnine per 10 lbs. grain. Unstarved pheasants, however, accepted this bait poorly and showed no signs of intoxication (Rudd & Genelly, 1956). Twenty grams of this bait would contain 125 mg. strychnine. Assuming a body weight of 1.2 kg, the total dosage for the starved pheasants amounted to 104 mg/kg, substantially more than the acute oral LD_{50} of 24.7 mg/kg. Pheasants typically eat 50-100 grams of grain feed per day (Tucker, Personal Communication 1978). Thus, if bait shyness did not occur, ingestion of lethal amounts of strychnine could occur.

d. Bioaccumulation and Tissue Residues

There is little evidence in the literature to indicate that elevated residues of strychnine can accumulate in animal tissue. Data from a study of 530 albino mice showed no accumulation of strychnine and no tolerance development to increasing dosages of the chemical. Detoxification seemed to be complete within the first 24 hours after administration (Kalning, 1968).

e. Secondary Toxicity

Low persistence of strychnine residues in tissues of animals greatly reduces the chance for secondary toxicity. However, unabsorbed residues in the gastrointestinal tract or cheek pouches of an animal ingesting a large dosage and quickly dying could be sufficient to poison a raptor or carnivore ingesting it. The calculation that fifty squirrels killed by strychnine would have to be eaten by a hawk for a fatal dose (Garlough and Ward, 1932) ignores this major source of risk. There is also a report, described briefly in Section I, of secondary poisoning of a kit fox as a result of ingesting strychnine-poisoned kangaroo rats under laboratory conditions (Schitosky, 1975).

f. Summary

Indications are that any likely potential field effects will not be the result of the compound's properties in regard to accumulation, chronic toxicity, reproductive effects, or secondary hazard from the consumption of flesh. Any potential for ecological vulnerability of terrestrial wildlife would appear to be the result of the high degree of acute toxicity by the oral (including dietary) route from either the bait or bait residue in the gastrointestinal tract or cheek pouches of poisoned animals.

3. Direct Risks to Nontarget Species

Since the purpose of placing strychnine treated bait in the field is to kill offending mammals and birds, it is obvious that a risk is present to individuals of many nontarget vertebrate species that may feed on the bait. The major issue is whether such feeding generally results in significant population reductions in the nontarget species. The best available information regarding this issue can be found in the observations of Hegdal and Gatz (1977a).

By using various methods to monitor the effects of applying 0.5 percent strychnine on steam-rolled oats to control ground squirrels in Wyoming, Hegdal and Gatz (1977a) determined that a majority of the territorial horned larks in the treated areas was killed, as were several blackbirds. Large numbers of mourning doves were also killed. The impact on certain other species of birds (vesper sparrows and meadowlarks) appeared to be substantially less (only three dead birds found).

The observed mortality varied substantially from area to area, presumably in relation to habitat details. For instance, of 19.5 ha searched, 42 percent (54/129) of all birds found dead were in a two ha plot in a wheatfield. Three "rangeland" plots totalling four ha produced only eight dead birds while a two ha lot in "crested wheat rangeland" yielded 24 bird carcasses. A two ha plot in alfalfa produced but a single bird carcass.

The observed impact on birds ranged from 0.5 to 27 deaths per ha. However, no conclusion can be drawn from the study as to whether the site (i.e. cropland, pasture and range, noncropland) had any effect on the risks to the birds. Therefore, extrapolation of the results of this study to predict the effects in other situations cannot be accomplished with a high degree of accuracy.

A reasonable conclusion is that reductions in local populations are likely but that the magnitude of this impact may vary with the species present and the area treated. Any long-term impact on vulnerable species could vary with factors such as the frequency of application, the scale of the operation and the distribution and abundance of the species. The Agency has no reason to believe that there are substantial geographical areas where strychnine might be used in surface baiting operations without exposure to one or more susceptible, nontarget species.

4. Indirect Risks to Nontarget Species

A potential for an indirect or secondary risk to vertebrates that feed on rodents killed by strychnine has been demonstrated (Schitosky, 1975). Translating this potential into realistic probabilities, however, should be done with caution. Sublethal doses of strychnine may be rapidly metabolized and eliminated from the body and, presumably, death occurs when this defense mechanism is overwhelmed by the dose. A general assumption, therefore, is that most of the strychnine absorbed by a victim has little potential for secondary poisoning; the major risk comes from the strychnine that may remain in the gut and in the cheek pouches.

If a 0.5 kg ground squirrel were to eat two g of a 0.5 percent strychnine bait, the ten mg of strychnine ingested may be just the lethal amount, since its LD_{50} is 20 mg/kg. Little or no strychnine would remain in the gut. Hegdal and Gatz (1977a) analyzed three Richardson's ground squirrels that apparently had been killed by strychnine. One contained 0.03 mg (2.8 ppm) strychnine in the stomach but no strychnine was detected at the limit of 0.5 ppm in the other two squirrels. These three squirrels would have posed little risk to any predator/scavenger. Three squirrels, however, are hardly an adequate sample and the Agency does not know the probability of a squirrel's consuming substantially more than a lethal dose of this rapidly acting poison. There is some evidence that ground squirrels poisoned by the strychnine remove the contents of the cheek pouches before dying (Stephl and Cates, 1928), but, again, the Agency has no reasonable measure of the level of pouched poison to be expected or the likelihood that such material will be ingested by predators and scavengers. The meager evidence suggests that secondary risk from ground squirrel control may be generally low.

On the other hand, should a prairie dog ingest the same two g of 0.5 percent strychnine, the situation may be quite different. Since the LD_{50} for prairie dogs is only 1.5 mg/kg as much as eight mg may remain in the gut. Such quantities of strychnine would be highly lethal for any swift fox or black-footed ferret that fed on the gut of the prairie dog. Again, data are not available as to how much bait a prairie dog is likely to consume before it dies, but it seems reasonable to conclude that the risk from eating a strychnine-poisoned prairie dog may be much greater than that from eating such a ground squirrel.

In the case of birds poisoned by strychnine, substantially more information is available. Hegdal and Gatz (1977a) analyzed the gastrointestinal tracts of 40 mourning doves apparently killed by strychnine baits. Of these birds, the maximum amount of strychnine found was 1.6 mg and the next highest amount was 0.86 mg. The median level was 0.1 mg strychnine. It should be noted that most of these spring immigrants were not exposed to fresh bait since they did not arrive until the baiting was well underway and that the strychnine level in the bait decreased progressively with time. The levels of strychnine in the doves also decreased according to the length of time elapsed after baiting before they consumed lethal doses. A reasonable assumption is that if most of the doves were killed on the day the bait was placed, the levels of strychnine in the gastrointestinal tract would have averaged somewhat higher. Nevertheless, of the amounts of strychnine found, most were not at levels that would be generally hazardous to scavenging vertebrates. Six of the 39 birds contained more than 0.5 mg strychnine and such amounts would be of toxicological significance only to small carnivores whose LD_{50}'s are in the 0.7 to 1.0 mg/kg range, such as the swift fox.

While the Agency cannot conclude that the available evidence is entirely adequate for an accurate risk assessment, the weight of the evidence suggests that the use of strychnine to control ground squirrels is not generally likely to create a high risk to nontarget species from secondary poisoning. Risks from prairie dog control, however, may be substantially higher.

5. Risks to Members of Endangered Species

Section 7 of the Endangered Species Act of 1973 (ESA) (16 USC 1531 et seq.) requires all Federal agencies, in consultation with and with assistance of the Secretary of the Interior, to take such action as is "necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of ... endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined by the Secretary .... to be critical." Accordingly, the Departments of the Interior and Commerce have established joint regulations implementing Section 7 of ESA, which include provisions for interagency cooperation and consultation concerning endangered and threatened species and their habitats (50 CFR 402, 43 FR 870-875).

On March 13, 1978, EPA requested formal consultation with the U.S. Department of Interior, Fish and Wildlife Service, under Section 7 of the Endangered Species Act of 1973, on the above-ground uses of strychnine as they affect endangered and threatened species.

As a result of that consultation, 43 endangered species were identified as likely to be exposed to strychnine as presently registered by EPA (Appendix D). These are listed as follows:

Endangered Species Likely to be Exposed to Strychnine

Reptiles

American Alligator (Alligator mississippiensis)

American Crocodile (Crocodylus actus)

Eastern Indigo Snake (Drymarchon corais couperi)

Birds

Aleutian Canada Goose (Branta canadensis leucopareia)

Hawaiian Goose (Nene) (Branta sandvicensis)

Marianas Mallard (Anas outstaleti)

Hawaiian Duck (Koloa) (Anas wyvilliana)

California Condor (Gymnogyps californianus)

Hawaiian Hawk (Buteo solitarius)

Bald Eagle (Haliaeetus leucocephalus)

American Peregrine Falcon (Falco peregrinus anatum)

Arctic Peregrine Falcon (Falco peregrinus tundrinus)

Attwater's Greater Prairie Chicken (Tympanuchus cupido attwateri)

Masked Bobwhite (Colinus virginianus ridgewayi)

Mississippi Sandhill Crane (Grus canadensis pulla)

Whooping Crane (Grus americana)

Hawaiian Gallinule (Gallinula chloropus sandvicensis)

Hawaiian Coot (Fulica americana alai)

Hawaiian Stilt (Himantopus himantopus knudseni)

LaPerouse's Megapode (Megapodius laperouse)

Puerto Rican Plain Pigeon (Columba inornata wetmorei)

Palau Ground Dove (Gallicolumba canifrons)

San Clemente Loggerhead Shrike (Lanius ludoricianus mearnsi)

Ponape' Mountain Starling (Aplonis pelzelni)

Yellow-shouldered Blackbird (Agelaius xanthomus)

Laysan and Nihoa Finches (Psittirostra cantans cantans; P.c. ultima)

Cape Sable Sparrow (Ammospiza maritima mirabilis)

Dusky Seaside Sparrow (Ammospiza maritima nigrescens)

San Clemente Sage Sparrow (Amphispiza belli clementae)

Mammals

Grizzly Bear (Ursus arctos horribilis)

Black-footed Ferret (Mustela nigripes)

San Joaquin Kit Fox (Vulpes macrotis mutica)

Red Wolf (Canis rufus)

Gray Wolf (Canis lupus)

Eastern Cougar (Felis concolor cougar)

Florida Panther (Felis concolor coryi)

Utah Prairie Dog (Cynomys parvidens)

Delmarva Peninsula Fox Squirrel (Sciurus niger cinereus)

Morro Bay Kangaroo Rat (*Dipodomys heermanni morroensis*)

Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*)

Key Deer (*Odocoileus virginianus clavium*)

Columbian White-tailed Deer (*Odocoileus virginianus leucurus*)

Sonoran Pronghorn (*Antilocapra americana sonoriensis*)

Strychnine's ability to kill members of endangered species is anticipated because strychnine is highly toxic to mammals and birds and strychnine-treated baits may be applied in areas inhabited by endangered species.

As with other nontarget species, those endangered species with feeding habits similar to target animals would be expected to eat the treated baits placed above ground for the target organisms. Additionally, indirect exposure may occur if predators or scavengers feed on the carcasses of strychnine victims, such as doves, ground squirrels, prairie dogs, and pigeons.

Of the 43 endangered species in the preceeding list, 18 were identified by the USDI as likely to be jeopardized if strychnine is used where these species are found. They are the Utah prairie dog, Morro Bay kangaroo rat, salt marsh harvest mouse, red wolf, masked bobwhite, dusky seaside sparrow, Cape Sable sparrow, Mississippi sandhill crane, Puerto Rican plain pigeon, Attwater's greater prairie chicken, yellow-shouldered blackbird, California condor, black-footed ferret, San Joaquin kit fox, gray wolf, and grizzly bear, Laysan finch and Nihoa finch. The Agency does not believe a possibility exists for strychnine use on the islands of Laysan and Nihoa, since they are not inhabited by man. Therefore, the Laysan and Nihoa finches will not be considered as needing special precautions. The specific use(s) of strychnine of concern for each of the other 16 species is discussed in Section V. The Agency believes that certain other species, the Peregrine Falcon and the Aleutian Canada Goose, require special concern. The following analyses provide the bases for the Agency's assessment of risks to the various species from the use of strychnine.

The Agency's interim procedure for estimating a "no effect" level in assessing risks to endangered bird and mammals (EPA, 1980) utilizes either a value of 1/5 the subacute dietary LC_{10} or 1/5 the acute LD_{10} expected to occur in or on the average daily intake of treated feed to which members of the species may be exposed. This information is not available for strychnine. The only basis for assessing risk consists of various LD_{50} values, anticipated exposure levels, and the knowledge that strychnine appears not to be cummulative in its effects.

Accurate use of the available data is hampered by the facts that the LD_{50} data provide no information on the range of individual variability and that interspecific sensitivity to strychnine is relatively high. The limited data base indicates that two species in the same genus (Microtus) have LD_{50}'s that differ by a factor of three and, within the same family, the chukar is seven times as sensitive as the California quail (Table III-1).

As an interim procedure for strychnine, the Agency will consider, for each endangered species, the suitability of the toxicity data in regard to related species, the probabilities of various exposures and the status of the endangered species in making determinations as to whether the margins of safety are sufficient.

a. The Black-Footed Ferret

This rare mammal is thought to be highly dependent on the existence of prairie dog colonies. Its present plight is doubtlessly due to the fact that prairie dogs have been eliminated over the majority of the acreage previously occupied. While further reduction of prairie dog acreage by whatever means cannot but serve to worsen the situation of the ferret, mere maintenance of the present prairie dog population by controlling with strychnine has a high potential for killing ferrets by secondary poisoning.

The USDI (Appendix D) has concluded that the use of strychnine to control prairie dogs could jeopardize the continued existence of the black-footed ferret. The Agency concurs in this opinion. While the critical habitat of the ferret has not been defined by the USDI, the Agency believes that any area now occupied by prairie dogs must be considered with great concern due to the relationship between the ferret and the prairie dog.

The USDI did not address the problem of controlling ground squirrels. White-tailed prairie dogs generally occur at lower densities than do black-tails and their populations are frequently intermixed with those of certain species of ground squirrels (Richardson's, Uinta and, to a lesser extent, Townsend's). For ground squirrel control grain bait is usually applied in the spring before green vegetation becomes available For prairie dogs, baiting is usually done in the late summer after the vegetation has become dry. Due to the different baiting seasons, prairie dogs are not especially vulnerable to control efforts aimed at ground squirrels, although some mortality can be expected (Hegdal and Gatz, 1977a).

Available data suggest that the use of strychnine to control ground squirrels is substantially less hazardous to the ferret than is the use to control prairie dogs. However,it must be recognized that a potential risk exists to the ferret if ground squirrel control is conducted when prairie dogs are present.

b. The San Joaquin Kit Fox

The USDI (Appendix D) has concluded that the use of strychnine within the area of this sub-species of the kit fox would jeopardize its continued existence. The Agency concurs in this opinion. The major target species within this area would be the California ground squirrel and, by extrapolation from limited data, the probability of risk to the kit fox would appear to be moderate were strychnine to be used for squirrel control. The use of strychnine to control birds in cropland poses negligible risk to the species since kit foxes are unlikely to range in those cultivated fields, orchards and vineyards where strychnine is used.

c. The California Condor

Only 25-35 individuals of this species remain (Wilbur, 1980) and the USDI concludes that "the loss of even one condor must be considered significant" (Appendix D). Current uses of strychnine in the condor's range are mainly for underground pocket gopher control and for horned larks and finches in cultivated land and orchards. The Agency concurs with the USDI that these uses are unlikely to expose condors to strychnine. A concern, however, remains for the potential use of strychnine to control ground squirrels.

While strychnine is registered to control ground squirrels, little, if any, is used for this purpose in the condor's range because compound 1080 is judged to be much more efficacious. Should this use of compound 1080 be cancelled under the RPAR process, use of strychnine could increase.

Of the species for which strychnine toxicity data are available, the one most closely related to the condor is the golden eagle, for which the LD_{50} is 5 mg/kg. For a nine kg condor, 45 mg strychnine may be highly lethal and an exposure of as much as two mg would not provide an acceptable margin of safety for this highly endangered species. This level of exposure can be obtained indirectly from consuming 0.4 g of a 0.5 percent bait. Such exposure from the use of strychnine for rodent control appears likely since the condor's diet consists entirely of dead animals including poisoned ground squirrels (Koford, 1953). While the amounts of strychnine to be expected in the carcasses of the poisoned animals are largely unknown, the potential for an excess of 0.4 g bait in a dead squirrel is easily visualized and the Agency must conclude that an ample margin of safety for the condor has not been demonstrated for this use of strychnine.

d. The Peregrine Falcon

The USDI concluded that peregrines could be adversely affected by a strychnine pigeon control program if proper precautions (unspecified) are not followed. Since there was no evidence of improper precautions the USDI opinion was that the continued use of strychnine is not likely to jeopardize the continued existance of the Arctic or American peregrine. Since that assessment, the Agency has received the following new information and conducted additional analyses that lead it to conclude that, when strychnine is used according to current practices for control of pigeons and ground squirrels, some risk to peregrine falcons is likely.

1. Several raptors, including owls and hawks, have been poisoned by strychnine in association with a control operation for pigeons in Duluth, Minnesota (Redig, 1978). This event clearly indicates that a potential exists for secondary poisoning of some species of raptors associated with this use of strychnine. Procedures such as pre-baiting flocks of pigeons and exposing them to high concentrations of bait are likely to maximize residue levels. Redig's (1978) observation that the dead raptors did not contain bait casts doubt on the generalization (derived from studies with rats) that the flesh of animals killed with strychnine is not hazardous.

2. A prairie falcon was killed during a pigeon control operation in Colorado in January 1980 (Locke, 1980). Similarities in the feeding patterns of prairie and peregrine falcons demonstrate the potential risk to the peregrine.

3. In Baltimore, Maryland, July, 1979, a young peregrine was observed to exhibit convulsions. Several days later, its body was found (Cade, 1980). Autopsy revealed feathers and seeds in the bird's stomach. Although a chemical analysis for strychnine had not been conducted at that time (Locke, 1980, personal communication), the presence of seeds in the falcon's stomach

demonstrates that peregrines could be exposed to strychnine bait in pigeon control operations.

4. Strychnine levels found in the gastrointestinal tracts of poisoned doves (Hegdal and Gatz, 1977a) were at a maximum of 1.6 mg and a median of 0.1 mg.Poisoned birds represent the most likely form of exposure for peregrines and 1.6 mg of strychnine would provide a dose of 3 mg/kg for a 0.5 kg bird and 1.5 mg/kg for a 1.0 kg bird. Compared to the LD_{50} of 5 mg/kg for a golden eagle, such a dose is of critical concern. The median exposure of 0.1 mg strychnine would be of marginal concern.

Whether a quantity of strychnine in the gut of a bird poses a risk to a peregrine depends on several circumstances. Peregrine falcons are unlikely to feed on carrion; a falcon must be on the scene when a poisoned bird is in distress. A flock of convulsing pigeons is much more likely to attract a falcon than is a single dove in convulsions. Having secured a poisoned bird, the risk to the falcon depends largely on how much strychnine is in the gastrointestinal tract and how much of that present is consumed. For pigeons and larger birds, the gizzard may be eaten intact but the contents of the crop are less likely to be eaten by a peregrine (Cade, 1980). For doves and smaller birds, the entire carcass may be eaten.

Risks to the peregrine falcon from the use of strychnine to control birds and rodents vary. If a falcon is in the vicinity of a pigeon control operation, the risks are high -- virtually every poisoned individual of the target species may be potentially lethal to a peregrine. The risks from birds poisoned incidental to the control of rangeland rodents are somewhat lower. About 15 percent of the doves analyzed by Hegdal and Gatz (1977) contained toxicologically significant levels of strychnine (>0.5 mg). In order for the use of strychnine to not jeopardize the continued existence of peregrine falcons, proper precautions beyond those currently being employed are necessary for ground squirrel and pigeon control. For sparrow control, however, little or no risk is probable because these small target species are unlikely to be fed on by peregrines.

e. Other Species

The Agency concurs with the USDI for the remaining species listed as likely to be jeopardized by the above-ground use of strychnine with the exception of the Laysan and Nihoa finches. In addition to the peregrine falcon, however, the Agency believes that the Aleutian Canada goose merits special concern due to a potential exposure to strychnine bait. These geese arrive in the Sacramento Valley in October, then move mainly to the upper San Joaquin Valley by winter. They generally return north to the vicinity of Crescent City in March and depart for the Aleutians in April (Woolington et al., 1979). Although ground squirrel control operations are not likely to take place at the time these geese are present on their wintering grounds, such operations could expose large flocks of geese to toxic baits.

6. Human/Domestic Risks

The lack of emergency treatment criteria was also examined in the PD1 in deciding if strychnine qualified as an RPAR chemical. After reviewing the available information, the conclusion reached was that an emergency treatment (activated charcoal, barbituates, and muscle relaxants) did exist and a presumption against registration because of that criteria was not warranted.

A recommendation was made by the Agency working group, however, for consideration of three points during the reregistration process. These are:

o Products with concentrations above 0.5 percent should be restricted to certified applicators.

o Dilute baits should only be available to untrained applicators when adequate packaging (child resistant containers), labeling, and use cautions are used.

o Intentional poisoning of domestic animals

Since the RPAR notice, additional data on morbidity and mortality have been analyzed. Data on poisonings, hospitalizations, and fatalities were obtained from four sources: 1) rodenticide poisonings and inquiries for the years 1974-1976 from the National Clearinghouse for Poison Control Centers, Food and Drug Administration, 2) hospitalization figures from "National Hospitalization Study of Acute Pesticide Poisoning, Admitted to General Care Hospitals", 1976, 3) mortality data based on episodes reported to the Pesticide Episode Reporting System (PERS) for the years 1967-1976, and 4) pesticide poisoning reports by Wayland Hayes, MD, PhD, Vanderbilt University School of Medicine (1956, 1961, 1969, 1973-74). The data for the three categories (poisonings, hospitalizations, fatalities) were thus from different sources and for different years.

For the years 1974-1976, 5,610 cases of inquiries and poisonings were reported for rodenticides. Of these, 26 were confirmed as being strychnine related. Since many cases do not specify the rodenticide, 26 is the lower bound on the number of strychnine poisonings. Fifteen of the 26 involved children under five years of age.

Hospitalization figures for 1971-1973, based on a 12 percent sample of general-care hospitals in the United States, were classified as being occupational, non-occupational,or intentional. Estimated numbers were obtained by multiplying each observation by eight to approximate hospitalization figures for all general-care hospitals. The estimated hospitalizations for unintentional, non-occupational strychnine poisonings ranged from 16 to 48 and totaled 88 for the three years. Twenty-seven percent of the cases involved children under five years of age (3 of 11).

Sixty four reports were located in the PERS files that involved strychnine (out of over 10,000 entries). Twenty eight reports involved humans, 28 involved domestic animals, five involved wildlife, and three were for environmental contamination.

Thirty people were affected in the 28 reports involving humans. Ten of the people died from strychnine poisoning.

Nineteen of the 28 reports were for incidents occurring in the home and all involved children age 15 or younger. Five of the 19 episodes resulted from the ingestion of strychnine baits placed in the home for rodent control. Two of the five resulted in fatalities. The other eight fatalities were one agricultural worker, two 15-year-olds who ingested LSD cut with strychnine (not a pesticide), three suicides, and two preachers who ingested strychnine as part of the religious service.

The Hayes studies reported a total of 21 deaths due to strychnine for the years 1956, 1961, 1969, 1973 and 1974. Four were children five years old or younger. Three of the 21 were also reported in the PERS data, leaving a total of 28 deaths reported in the two sources. These are not the total deaths due to strychnine, but rather those deaths that were documented for specific years.

Domestic use also includes areas where pets may be in contact with a pesticide (40 CFR 162.3 (m)). As stated earlier, the PERS data contained reports of 28 domestic animal poisoning incidents. Twenty-six incidents were home related and all involved dogs (one also involved cats). Twenty-three of the incidents were fatalities (86 dogs and 5 cats). The majority of the poisonings resulted from undetermined sources (14 reports) or intentional poisonings (10 reports). Two resulted from ingesting rodent control baits (two dogs).

In summary, the availability of strychnine for domestic use has resulted in human and pet poisonings and fatalities. For the years 1974-1976, 26 cases of strychnine poisonings and inquiries were reported. Fifteen involved children five years old or younger. For the years 1971-1973, an estimated 88 hospitalizations occurred for unintentional, non-occupational strychnine poisonings. Twenty-seven percent involved children five years old or younger. For the years 1956 through 1976, 28 deaths were reported. Six of the 28 were children five years old or younger.

Although emergency treatment is available and possible, as concluded in PD 1, it must begin within 30 minutes of ingestion. The case histories examined for PD 1 did not include any fatalities. The data reviewed since then indicates a risk to humans, particularly to children. Most of the hospitalizations and fatalities, however, involved strychnine use that was unrelated to rodent control, (e.g. suicide) or a misuse of the rodenticide. Also, as stated in Section I, strychnine products with concentrations greater than 0.5 percent are now restricted for use only by certified operators. The Agency is of the opinion, therefore, that the human risk from the registered uses of strychnine that are the subject of this RPAR are not sufficient to warrant the consideration of regulatory actions.

B. Alternatives - Mammals

1. Sodium Fluoroacetate (Compound 1080)

A rebuttable presumption against registration was issued by the Agency for compound 1080 in December, 1976. Its use as a strychnine alternative will depend on the result of the RPAR review currently underway. The following discussion in no way implies its continued availability.

a. Method of Application

1) Ground Squirrel

Sodium fluoroacetate (compound 1080) is registered in California, Nevada, and Colorado used for ground squirrel control as a spot bait on bare ground near burrows. It is also ground applied by mechanical broadcaster or aerially applied in approximately 30-foot-wide swaths. The baits are usually made with oat groats, barley, chopped cabbage, or chopped dandelion greens. The concentration of compound 1080 in the various baits ranges from 0.05 percent to 0.12 percent. When hand applied it is most often accomplished by scattering a teaspoon to a tablespoonful over two to three square feet of bare ground near each active burrow. When applied by air or broadcast, about five-six or five-ten pounds per swath acre are used. Treatments are usually in the late spring.

2) Prairie Dog

A single state registration for prairie dog control (Colorado) was found for an 0.11 percent grain bait with yellow dye. According to the product use directions, the bait is to be scattered over three square feet near burrows, but the amount per bait placement was not stated.

b. General

1) Toxicology

Compound 1080 is essentially colorless, odorless, and nearly tasteless (Atzert, 1971). The onset of signs and symptoms of poisoning generally occur after a delay period which would allow ingestion of a complete meal containing the toxicant before effects commenced. Regurgitation is not commonly induced by compound 1080. For these reasons bait acceptance is usually excellent.

Because the LD_{50}'s by intravenous and oral routes are usually similiar, it can be inferred that compound 1080 is well absorbed from the gastrointestinal tract. Gal, et al. (1961) determined by radioisotope tracer technique upon rats that intraperitoneally administered compound 1080 was rather evenly distributed in the animal four hours post administration. Little had been expired as $^{14}CO_2$ or excreted in the urine. It is generally thought that compound 1080 is not changed in the body to any great extent and is largely eliminated in the urine intact.

Signs and symptoms of compound 1080 poisoning vary. However, they may be classified into three categories: CNS (central nervous system), cardiac, and depression syndromes. The CNS syndrome is characterized by hyperactivity, phonation, tonic spasms and convulsions which lead to respiratory paralysis. The cardiac syndrome is associated with blanching of the retina, muscular weakness, clonic convulsions, and ventricular fibrillation. The depression syndrome is associated with decreased activity, respiratory depression, and bradycardia. Additionally, muscarinic effects are produced in certain species of terrestrial wildlife such as ferrets. The onset of symptoms of poisoning almost always exceeds 1/4 hour and death most often occurs between one hour and one day after ingestion of a lethal dosage. Long latent periods preceding symptoms are common.

The development of pathologies is frequent, even after single dosages. Definite histologic abnormalities in the myocardium have been reported (Chenoweth, 1950). Hemorrhagic changes in the liver, heart, aorta, and brain are sometimes evident. Gastrointestinal purpura and petechial pulmonary hemmorrhages particularly occur in poisoned mammals.

Biochemically, compound 1080 is thought to exert its toxic effect by inhibition or blocking of citrate and succinate metabolism within the Kreb's cycle (Atzert, 1971).

2) Acute Toxicity

a) Laboratory Data

Table III-2 gives a summary of acute oral toxicity figures of compound 1080 for numerous species of mammals, amphibians, and birds. The median lethal single oral dosages (mg 1080 per kg. animal wgt.) range from a very low figure of 0.056 mg/kg for nutria to 60 mg/kg for the opossum. Even though a 1000-fold range in susceptibility exists between species, all species listed are very sensitive to the toxic action of compound 1080. Relatively few pesticidal chemicals in use are more orally toxic than compound 1080.

Generally, mammals are most sensitive, notably nutria, prairie dog, kit fox, other members of the dog and cat families, and the big brown bat. Over a third of the species listed in the table exhibit LD_{50}'s below one mg/kg. This compound, like strychnine, is not readily absorbed through intact skin. Inhalation contact for wildlife is not likely (Pattison, 1959).

b) Field Studies

Under an Environmental Protection Agency (EPA) Interagency Agreement, the U.S. Fish and Wildlife Service, Denver Wildlife Research Center (DWRC) evaluated the hazards to wildlife associated with aerial 1080 baiting for California ground squirrels. The study was conducted in Tulare County, in south-central California, in the eastern foothills of the San Joaquin Valley. The study monitored a large-scale operational baiting program conducted by the Tulare County Agricultural Commissioner.

During early June 1977, (in the vicinity of the study area) about 25,000 ha (60,000 acres) were spot-treated with 0.075 percent 1080-treated oat groats at about 6.7 kg/ha (6 lb per swath acre). The actual surface area baited was about 3.4 percent of the range.

TABLE III-2 - ACUTE ORAL TOXICITY OF COMPOUND 1080[1]

SPECIES	LD$_{50}$ mg/kg[2]	REFERENCES[3]
I. MAMMALS		
A. RODENTS		
Wood rat	1.5	Chenoweth
Calif. Ground squirrel	0.35	DWRC Files
Tuza pocket gopher	0.25 (60%)	Howard and Marsh
Northern pocket gopher	0.33	DWRC Files
Fresno kangaroo rat[4]	1.0 (100%)	DWRC Files
Polynesian rat	6.60	DWRC Files
Black rat	0.10	Chenoweth
Norway rat	0.22-3.0	Chenoweth
White rat (male)	2.1	DWRC Files
White rat (female)	2.2	DWRC Files
Cotton rat	0.1	Chenoweth
Rice rat	3.4	DWRC Files
House mouse	8.0	Chenoweth
White mice	12.0	Chenoweth
Meadow mouse	0.5	Chenoweth
Meadow vole	0.92	Atzert
Deer mouse[4]	4.0-5	Howard and Marsh; Chenoweth
Plains prairie dog	0.3 (100%)	Howard and Marsh
Plains prairie dog[4]	0.9 (100%)	Howard and Marsh
Black-tailed prairie dog	0.33	DWRC Files
Nutria	0.056	Atzert
B. DOMESTIC MAMMALS		
Hereford cows	0.393	Robinson
Hereford calves and steer	0.221	Robinson
Mules (M & F)	0.22-0.44	Tucker and Crabtree
Horse (M & F)	0.35-0.55	Tucker and Crabtree
Swine (M & F)	1.0	Chenoweth
Sheep	0.25-0.50	Atzert
Dog, mixed breeds[5]	0.06	DWRC Files
C. OTHER MAMMALS		
Man (children only)	2.0 est.	Howard and Marsh
Rhesus Monkey	4.0	Chenoweth
Mule deer (Male)	0.30-1.00	Tucker and Crabtree
Domestic ferrets (Male)	1.41	Tucker and Crabtree
Big brown bat	0.15	DWRC Files

1/ Oral Toxicity by gavage unless otherwise indicated.
2/ If % mortality other than 50%, this appears in parentheses after the mg/kg figure.
3/ DWRC indicates Denver Wildlife Research Center.
4/ Voluntary Feeding
5/ Intravenous

TABLE III-2 - ACUTE ORAL TOXICITY OF COMPOUND 1080 (Continued)[1]

SPECIES	LD_{50} mg/kg[2]	REFERENCE[3]
Commercial mink	0.49	DWRC Files
Desert kit fox	0.22	DWRC Files
Black-tailed jack rabbit	5.55	DWRC Files
Opossum	60.	Atzert
Black Bear	0.5-10	Atzert
Bobcat[6]	0.66	Atzert
II. AMPHIBIANS		
Bull frog (Male)	54.4	Tucker and Crabtree
III. BIRDS		
A. RAPTORS		
Golden eagle	1.25-5.0	Tucker and Crabtree
American rough-legged hawk[4]	10.0	Howard and Marsh
Marsh hawk[4]	10.0	Howard and Marsh
Great horned owl[4]	10.0	Howard and Marsh
Turkey vulture	20.0 (71%)	Howard and Marsh
Black vulture	15.0	Howard and Marsh

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[1] Oral Toxicity by gavage unless otherwise indicated.
[2] If % mortality other than 50%, this appears in parentheses after the mg/kg figure.
[3] DWRC indicates Denver Wildlife Research Center
[4] Voluntary Feeding
[5] Intravenous
[6] Intraperitoneal

TABLE III-2 - ACUTE ORAL TOXICITY OF COMPOUND 1080 (Continued)[1]

SPECIES	LD_{50} mg/kg[2]	REFERENCE[3]
B. **GAME BIRDS**		
Gambel's quail (young)[4]	10.	Chenoweth
Pigeon	4.24	Tucker and Crabtree
Mourning dove	8.55-14.6	Tucker and Crabtree
Ring-necked pheasant (Male)	6.46	Tucker and Crabtree
California quail (Female)	4.63	Tucker, et al.
Chukar partridge (M & F)	3.51	Tucker and Crabtree
Coturnix (Male)	17.7	Tucker and Crabtree
Merriam's turkey (Female)	4.0	Tucker and Crabtree
C. **PASSERINES**		
Brewer's blackbird[4]	2.0-3.0 (33%)	Howard and Marsh
English sparrow	3.00	Tucker and Crabtree
Magpie	0.6-1.3	Atzert
D. **WILD WATERFOWL**		
Mallard (Male)	9.11	Tucker and Crabtree
Mallard (Female)	15.0	Howard and Marsh
Pintail (Male)	10.0	Howard and Marsh
Pintail (Female)	8.0	Howard and Marsh
Widgeon (Male)	3.0	Howard and Marsh
White-fronted goose	5.90	Tucker and Crabtree
E. **DOMESTIC BIRDS**		
White leghorn chicken	7.5	Chenoweth
Rhode Island red chicken	5.0	Chenoweth
Pigeon - Florida	10.0 (42%)	Howard and Marsh
Pigeon - Colorado[4]	2.0-3.0	Howard and Marsh

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[1] Oral Toxicity by gavage unless otherwise indicated.
[2] If % mortality other than 50%, this appears in parentheses after the mg/kg figure.
[3] DWRC indicates Denver Wildlife Research Center
[4] Voluntary Feeding

California ground squirrel populations were reduced about 85 percent following baiting. Primary hazards to seed-eating birds appeared minimal as indicated from intensive carcass searching and the results from 31 radio-equipped mourning doves and ten radio-equipped California quail. One of two white-breasted nuthatches found dead after treatment contained compound 1080 residue. One of two samples of dead ants also contained compound 1080 residue. Twelve cottontail rabbits were found dead after treatment and four contained 1080 residue, indicating some primary hazard to this species.

Secondary hazards to raptors and mammalian predators were evaluated by attaching radio transmitters to 24 raptors (red-tailed hawks, turkey vultures, a golden eagle, great horned owls, barn owls, a screech owl, common ravens, a common crow), and 42 mammalian predators (bobcats, coyotes, gray fox, badgers, striped skunks, raccoons, and opossum) and monitoring their movements before, during, and after treatment. Five of the six radio-equipped coyotes and three of the ten radio-equipped bobcats (one bobcat was emaciated, possibly the result of a trap injury) were found dead after treatment. Three dead striped skunks (not radio-equipped) were also found dead after treatment and one contained compound 1080 residue. No other treatment-related mortalities were indicated among the remaining radio-equipped birds or mammals. Also, monitoring of 58 active raptor nests indicated no treatment-related mortalities.

3) Subacute and Chronic Toxicity

While it was determined that the single oral LD_{50} of compound 1080 for mallards was 9.11 mg/kg, repeated oral dosages of just 0.5 mg/kg/day for 30 days produced mortality in the same mallard stock. Relative to a number of other pesticides, this indicates a moderate to high degree of cumulativ toxic action for this species (Tucker and Crabtree, 1970).

Repeated sublethal doses of compound 1080 have increased the tolerance of some species to subsequent challenging doses. This increase in tolerance is most often slight, however. In other species, such as in the mallard, cumulative intoxication occurs. Accumulation and tolerance for compound 1080 are time-related phenomena such that short-interval treatments (less than 30-hr. spacing) are more likely to accumulate. Longer interval treatments (three or more days apart) are more likely not to have cumulative effects. Reports concerning effects of long-term feeding upon low levels of compound 1080 were not found.

4) Bioaccumulation and Tissue Residues

As previously stated, the distribution of compound 1080 in animal tissues after ingestion is widespread and somewhat evenly concentrated in most soft tissues of the body. Residue chemists often use the whole carcass, or stomach and intestinal tract, as the sample for analyses in suspected compound 1080 poisoning cases. Massive concentrations can be found in the gastrointestinal tract, but residues are not frequently found in higher than LD_{50} amounts in absorbed form.

Thus, tissue residues in compound 1080-killed animals may not exceed the LD_{50} amount and in many cases may be somewhat lower than the LD_{50} while gastrointestinal contents may sometimes be much higher.

Rats fed 5.8 mg/kg were killed after five hours and tissues analyzed. Heart, brain, kidney, skin plus hair, and whole carcass contained five ppm (Rudd and Genelly, 1956). In summary, compound 1080 does not tend to accumulate to any great degree. Death of the animal normally prevents great residue buildup in any tissue or organ system except the gastrointestinal tract.

5) Secondary Toxicity

Several laboratory studies lead to the conclusion that secondary poisoning of animals (poisoning of animals which eat a species directly exposed) can readily occur with compound 1080. Chemical stability of compound 1080 would favor the possibility of secondary poisoning.

Tucker (1965-72) offered domestic ferrets the intact bodies of albino rats which had been stomach-tubed with compound 1080 two hours previously. As the ferrets ate their respective rats over several days, the stated amounts (expressed as mg of compound 1080 per kg of ferret) were not ingested at once nor completely and represented much higher than the actual dosage to the ferrets. Even so, ferrets eating rats containing dosages of 2.0 mg/kg or less exhibited strong symptoms while 8.0 mg/kg and above on this basis was fatal to ferrets.

A similar experiment by Tucker with Peromyscus sp. and ferrets produced death in ferrets if the mice eaten had been stomach-tubed to contain one mg 1080/kg or more for the ferret. The acute oral LD_{50} of 1080 stomach-tubed in aqueous solution directly to ferrets was found to be 1.41 mg/kg. If fed in ground beef, the LD_{50} was between one and two mg/kg. It was concluded that a ferret which receives two mg/kg whether by direct ingestion or by feeding upon a prey species is very likely to succumb and that levels as low as 0.5 mg/kg can produce severe symptoms lasting up to a week. From this, it was considered likely that a 650-gram ferret ingesting 1.3 mg (2 mg/kg) of 1080 could die. This would mean that if a little as 1.0 gram of a 2 oz/100 lb. (0.125 percent) bait were ingested directly by a ferret it would likely be lethal. If compound 1080-poisoned prairie dogs were fed upon by black-footed ferrets a similar hazard could exist. The domestic ferrets in these studies ate all parts of the mice completely and variable parts of the rats, including the gastrointestinal tract. Some left only portions of the pelt.

In an experiment by Rudd and Genelly (1956), a dog was killed by eating the heart tissue of a horse five hours after the horse had eaten 4.41 mg/kg of compound 1080.

6) Human Risks

The RPAR notice against compound 1080 was based on three criteria, one of them being the lack of emergency treatment for human poisoning. Since the RPAR review has not been completed on this chemical, the treatment question cannot be addressed here. The data on potential risks, however, will be presented.

The USDI reported 22 human poisonings with compound 1080 for the period 1946-1949. This period was the first 4 years of compound 1080 use as a rodenticide, and before use was restricted and controlled. Of these 22 cases, four were reported as suicides and 16 were accidents involving children. Two were accidental adult poisonings. Eleven of the 16 children died. One of the two adults died.

More recently, reports of three cases of human poisonings have been published. Two (1970 and 1975) were accidents involving children. Both survived. One child was reported to have suffered neurological damage. A third accident involved an adult, said to be a suicide. EPA's Registration files contain a report of the accidential fatal poisoning of a man, who ingested 436 mg (estimated) of compound 1080 from a bottle left by a licensed pest control operator.

Another case (1968) was reported in the rebuttal from the California Department of Food and Agriculture (30000/7:#82) and involved a child, who recovered following hospitalization.

Eighteen accidental cases and four cases alleged to have been suicides were reported for the four years ending with 1949. For the period 1950-1976, nine poisonings were reported. For these 26 years, the average was approximately one poisoning every 2 1/2 years.

The completeness of accident reports can always be questioned but it appears that there have been few human poisonings by these compounds since restrictions and controls were placed on compound 1080. The greatest hazard is still in and around the home.

The EPA's PERS reports, for the period 1972- May 1976, include 94 to 104 (the number in one group was estimated as 40 to 50) poisoning deaths of domestic pets associated with compound 1080. These include 69-70 confirmed compound 1080 pet poisonings. Forty-four to fifty-five were considered the results of deliberate vandalism using compound 1080. Four were identified as occurring in locations near industrial sites where compound 1080 was used. Five were near a home where mice had been poisoned with compound 1080 by a pest control operator. This last group of poisonings occurred in 1975.

2. Zinc Phosphide

a. Method of Application

1) Ground Squirrel

Oat groat, rolled oat, cabbage or dandelion baits are used for zinc phosphide. The concentration of the active ingredient in the bait varies from 0.5 percent to 2.0 percent. Baiting is accomplished by scattering a tablespoon of bait over two to three square feet at the side of a burrow on bare ground or around rock or log piles used by ground squirrels. Such bait may be broadcast by ground equipment or by airplane at about six pounds per swath acre. Zinc phosphide is registered in California and Nevada for this use.

2) Prairie Dog

A 2.0 percent steam-rolled oat bait is placed in a heaping teaspoon (4 gm) amount on open ground near a burrow. Formerly, heaping tablespoon amounts (14 gm) per bait placement were recommended. Usually the rate works out to about 0.35 pounds of bait per acre. The label recommend baiting in late summer or fall. Zinc phosphide is federally registered for this use.

b. General

1) Toxicology

Zinc phosphide is a heavy, finely ground gray-black powder that is practically insoluble in water and alcohol. When exposed to moisture, it decomposes slowly and releases phosphine gas. Phosphine, which is highly flammable, may be generated rapidly if the material comes in contact with dilute acids. Zinc phosphide concentrate is a stable material when kept dry and hermetically sealed.

When zinc phosphide comes into contact with dilute acids in the stomach, phosphine (PH_3) is released and it is this substance which probably causes death. Animals that ingest lethal amounts of bait usually succumb overnight with terminal symptoms of convulsions, paralysis, and coma. Death usually results from asphyxia. If death does not occur for several days, intoxication occurs similar to that observed with yellow phosphorous in which the liver is heavily damaged. The surface of the liver is spotted and discolored. Prolonged exposure to phosphine can produce chronic phosphorous poisoning. To this extent, zinc phosphide may possess some characteristics of accumulative toxic materials.

Early symptoms of zinc phosphide poisoning are: nausea, vomiting (yielding black stomach contents and smell of phosphine), abdominal pain, chest tightness, excitement, and a feeling of coldness. In fatal cases, there is liver, kidney and heart damage. The time between ingestion and death is frequently about 30 hours. Victims who are alive three days after exposure are said to recover completely. Mild poisoning from breathing minute amounts of phosphine gas can be mistaken for food poisoning because of the diarrhea and stomach pains produced.

Zinc phosphide baits have a strong, pungent, phosphorous-like odor (garlic-like), this characteristic seems to attract rodents, particularly rats, but apparently makes the bait unattractive to some other animals.

2) Residue

In soil, zinc phosphide breaks down rapidly to phosphine which is either released into the atmosphere or converted to phosphates which remain as a residue and zinc complexes.

There is only a small amount of deterioration of zinc phosphide on baits due to the evolution of phosphine gas; therefore, dry baits must be considered to be toxic indefinitely and must be used accordingly. Lecithin-mineral oil, added to zinc phosphide to adhere it to grain bait, offers protection aginst moisture, and therefore, may increase its stability. Under field conditions, zinc phosphide baits may remain toxic for several months until eroded by weathering or decomposition of the carrier or the grain is removed by insects. Physical erosion does not seem to occur rapidly. In one instance zinc phosphide-treated bait, exposed in the field for two to three months and ten to twelve inches of rain, continued to maintain some toxicity.

Residues of zinc phosphide in treated baits collected from the ground were at 1/3 of pre-treated amounts by one day post-treatment but did not further decline for 21 days. About ten percent of the original residue was found 200 days post-treatment (Hegdal and Gatz, 1977).

3) Acute Toxicity

a) Laboratory Data

A 2.5 percent zinc phosphide wheat bait single oral LD_{50} for ring-necked pheasants was determined to be 1067 mg/kg. This value is equivalent to 26.7 mg/kg actual zinc phosphide. For the gray partridge (*Perdix perdix*), the LD_{50} was 16.0 mg/kg for zinc phosphide. On this basis 18 to 25 poisoned wheat kernels would be lethal to some pheasants and six to nine kernels would be lethal to some partridges. Neither zinc phosphide nor the red color on the bait prevented the birds from consuming the grains. More than 80 percent of the bait strength remained after 3-27 days exposure to weather including multiple rains (Janda and Bosseova, 1970). There is evidence that black dye on bait exerts some repellency to bobwhite quail (Hines and Dimmick, 1970).

The oral LD_{50} of zinc phosphide to a wide array of avian species lies in the 10 to 30 mg/kg range. Among the more sensitive are geese (7.5 - 8.8 mg/kg), pheasants (8.8 - 26.7 mg/kg) and California quail (13.5 mg/kg) (Tucker and Crabtree, 1970). A 5-day dietary LC_{50} for mallard ducklings was reported to be 1285 ppm (Hill, et al. 1975). Ungulate and carnivorous mammal LD_{50} values are 40-50 mg/kg. Most rodents are in the 15-40 mg/kg range with exceptions (nutria, 5.6; northern pocket gopher, 6.8; kangaroo rats, 8.0 mg/kg). The jackrabbit LD_{50} is 8.2 mg/kg (Hood, 1972).

b) Field Studies

A field study (Collins, 1966) used 8-14 pounds of two percent zinc phosphide with oat groats (not cracked corn) aerially applied to 96 miles of ditches and canals for rat control, researchers found seven dead and 71 live pheasants along the route. Other dead nontarget animals included two mallards, two bitterns, and one rabbit. Whether zinc phosphide was the cause of the deaths was not determined by residue analysis.

The degree of persistence of the toxicity of two percent cracked corn zinc phosphide baits is shown by data of Hayne (1951). When such baits are allowed to weather outdoors, the laboratory mouse LD_{50} from dosing with these baits increased from 2.8 mg/kg as zinc phosphide on day zero to 4.4 mg/kg in 4-6 days, to 14.6 mg/kg in 27 days (USDI, May, 1974).

In a nontarget wildlife safety study done under field conditions (Hegdal and Gatz, 1977), some mortality among rabbits and pheasants resulted from orchard mouse control on several square miles of orchards with zinc phosphide. Chemical residue analyses established zinc phosphide poisoning as the cause of the mortality. One blue jay was also killed by zinc phosphide. Otherwise, raptors, predatory mammals, passerines, gallinaceous birds, waterfowl, and avian scavengers suffered no observed mortality. Radiotelemetry tracking of nontarget wildlife provided a useful tool in monitoring the effects.

4) Secondary Toxicity

Golden eagles, great horned owls, and coyotes receiving multiple feedings of zinc phosphide-poisoned jackrabbits showed no signs of secondary intoxication (Evans, 1970).

Bell and Dimmick (1975) briefly describe several secondary hazard tests with zinc phosphide involving the feeding of prairie voles to red foxes. Two individuals were fed voles which were dead or dying from zinc phosphide treatment at 5.3 times the LD_{50} for the voles (a total of 86.94 mg/kg). The red foxes consumed 11.5 voles each in 3 days or 10.64 mg/kg zinc phosphide (if the toxicant had been unaltered) and survived though exhibiting briefly altered behavior. The study concluded that "little hazard...may" exist from secondary poisoning.

Zinc phosphide failed to be lethal in a study in which secondary toxicity of compound 1080 and strychnine was shown for kit foxes ingesting poisoned kangaroo rats. These foxes survived repeated feedings of kangaroo rats each killed by 480 mg of zinc phosphide. This is equivalent to 3 times the LD_{50} for a kit fox and 29 times the amount one kangaroo rat might consume in field-applied baits (Schitoskey, 1975). The direct dose LD_{50} of zinc phosphide for the kit fox was 93 mg/kg.

Collectively, the literature on secondary poisoning for zinc phosphide shows the low probability of secondary hazard to predatory wildlife which consume target rodents (USDI, April, 1976). Some risk to predators may be associated with the consumption of bait stored in the cheek pouches of certain rodents.

5) Human Risks

No reports of dermal toxicity determinations were found. Although the pesticide is toxic when inhaled, no LD_{50} figures are available. The Agency has no data on skin or eye irritation, but workers are required to wear gloves when prepairing or handling baits to prevent skin contact.

3. Anticoagulants

a. Methods of Application

CPN (Chlorophacinone) ground squirrel grain baits (usually oat groats or chopped cabbage or dandelion greens) range from 0.005 percent to 0.01 percent CPN. Typically, about one to five pounds of bait are placed in a bait box or hopper bait station intended to exclude wildlife larger than the squirrel. Bait is replenished every few days to give 1-to-4 week repeated exposure to the squirrels. Some labels call for broadcasting a handful of bait every other day, three times over a 40-50 square foot area near each burrow or runway.

The methods and rates of DPN (Diphacinone) application are nearly identical to those for CPN given above. Residue persistence data for CPN and DPN were not found.

The other anticoagulants, Pival, Fumarin, Warfarin, PMP, and Talon, are applied in a nearly identical manner as CPN, but the concentration of the active ingredient is approximately five times greater than for CPN.

b. Toxicity

1) CPN

Chlorophacinone (CPN) causes death from internal bleeding by hindering blood clotting and increasing capillary permeability.

A great degree of species selectivity occurs with CPN. Rodents such as pine voles and deer mice have single oral LD_{50} values of 3.58 mg/kg and 0.49 mg/kg, respectively. On the other hand, the LD_{50} values for red-winged blackbirds, mallards, and ring-necked pheasants are 430, greater than 100, and greater than 100 mg/kg, respectively (Giban, 1969).

In 1969, Giban conduted an experiment to measure the toxic effects of CPN 0.0075 percent baits on the gray partridge during a 15-day exposure. A daily oral dose of 2.25 mg CPN per bird was calculated to be the equivalent of free-feeding on 0.0075 percent baits. All 10 partridges survived 15 consecutive daily doses of 2.25 mg. None of 10 survived this level for 30 daily doses. Seven of 10 survived 15 daily doses of 4.5 mg/bird (Giban, 1969).

2) DPN

Diphacinone (DPN), as with CPN, causes death from internal bleeding by hindering blood clotting and increasing capillary permiability. With the amounts of DPN used in baits, rodents must ingest several bait applications in order to receive a lethal dose. DPN is also used in human medicine as an anticoagulant.

The acute oral LD_{50} in rats of the technical material is 2.31 mg/kg. An acute dermal LD_{50} was not found in the literature. It was reported that three or four rabbits were killed in a dermal toxicity test in which a 200 mg/kg dose was used.

The Velsicol Chemical Corporation (1976) reported the average 5-day dietary LC_{50} of DPN (technical) to be 4485 ppm for 14-day-old bobwhite quail. Concentrations of 1000 and 2150 ppm produced 10 and 20 percent mortality. A similar study with 14-day-old mallards found an LC_{50} of greater than 10,000 ppm, although 20 percent mortality and reduced food consumption occurred at this level. (Velsicol Chemical Corporation, 1976).

Truslow Farms, Inc. (1976) reported on an eight week secondary toxicity study with sparrow hawks (*Falco sparverius*) in which 0.005 percent DPN baits were fed to Swiss mice for three to five days. Six wild hawks (which had been trapped) received two treated mice each day. After 10 days of exposure the hawks were fed untreated mice and held for six weeks observation. There was no effect upon the hawks except lack of weight gain. The mice were terminally poisoned at the time of ingestion by the hawks as shown by studies on identically treated mice not fed to the hawks.

Mendenhall and Pank (unpublished) demonstrated a potential hazard to avian predators of secondary poisoning from DPN in an experiment using three species of owls. Two DPN poisoned mice were fed twice daily to the owls for five days. The mice had consumed a lethal dose of 0.01 percent DPN bait over a 10-day period. Three of the four owls in the test died 7-14 days after the experiment began.

3) Other Anticoagulants

The effects of the other anticoagulants, Warfarin, Pival, Fumarin, PMP, and Talon are similar to CPN and DPN in that they all cause death through hemorraging. Repeated doses are generally required to cause death.

c. Human Risks

1) CPN

Human volunteers were given a 20 mg/kg dose and their prothrombin ratings were monitored for eight days thereafter. The rating fell to 35 percent of normal, but it almost completely recovered by the end of the study. It was concluded that ingestion of 400 g of a bait containing 0.005 percent chlorophacinone would depress prothrombin activity to dangerously low levels.

Pesticide Incident Monitoring System (PIMS) files for the year 1966 to June 1979 contain nine reports on CPN poisoning. Five of the reports involved children, one report involved an adult, and the other three involved animals. None of the human incidents were fatal.

2) DPN

The Agency has no data on the human risks associated with the use of DPN as a rodenticide.

3) Other Anti-Coagulants

The Agency has no data on the human risks associated with the use of Warfarin, Pival, Fumarin, PMP, or Talon as a rodenticide.

4. Fumigants

a. Carbon Disulfide

Carbon disulfide is a highly volatile liquid which boils at 84.1°C (183.4°F). Its LD_{50} (subcutaneous in rabbits) is 300 mg/kg.

Carbon disulfide vapor is absorbed largely through the lungs, although toxic quantities can also be absorbed through the skin. Its effects are mostly on the nervous system; single exposures are characterized by narcosis and its sequelae. Human symptoms of repeated exposure are nervousness, irritability, indigestion, bizarre dreams leading to insomnia, excessive fatigue, loss of appetite, headaches, euphoria, restlessness, mocous membrane irritation, nausea, vomiting, unconsciousness, and terminal convulsions.

PIMS files for the period 1966 to August 1979 contain 21 reports of carbon disulfide exposure through inhalation . Eleven incidents involved carbon disulfide alone. The other ten cited carbon disulfide in combination with other ingredients. Five fatalities resulted, all adults, and all from exposure of fumigants where carbon disulfide was one of two or more active ingredients.

b. Gas Cartridges

Gas cartridges emit gases, mostly carbon monoxide, and smoke when ignited. The cartridges are cardboard cylinders filled with sulfur, charcoal, red phosphorus, mineral oil, sodium nitrate, and sawdust.

The affects on animals is assumed to be the same as those on humans, i.e., unconsciousness followed by a drop in blood pressure, loss of muscular control, and finally a stoppage in breathing.

c. Methyl Bromide

Methyl bromide is a colorless liquid that boils at 4.5°C (40.1°F). It is 3.5 times heavier than air, has a burning taste, and an odor resembling that of chloroform. Methyl bromide is usually packaged, under moderate pressure, in metal cylinders.

The effects of methyl bromide are on both the respiratory and central nervous systems. The central nervous system effects occur with or follow the respiratory system effects by several hours. Respiratory effects include coughing, chestpains, painful breathing, and broncho-pneumonia. Central nervous system effects include nausea, vomiting, blurred vision, convulsions, muscle weakness, and respiratory paralysis.

Methyl bromide can cause burns if allowed to saturate clothing, or if splashed in the eye.

d. Other Fumigants

Calcium cyanide is applied as a dust for house mouse control. For woodchuck control, it is applied either as a solid or a dust. Death is caused by respiratory arrest, following nausea, unconsciousness, convulsions, and paralysis. Reactions to the gas occur within seconds after inhalation, and death results within minutes.

Carbon tetrachloride (under RPAR review), paradichlorobenzene, and ethylene dichloride, all contained in one product, are applied as a liquid. Death results from either respiratory arrest or circulatory collapse.

5. Repellants

The repellants Hinder and Thiram are sprayed on plants and trees prior to the onset of damage. No risks to nontargets are anticipated since these are not toxicants.

6. Relative Risks and Comparative Data

Data for making precise comparisions of relative toxicity are not abundant; however, some reasonable generalizations can be derived from Table III-3. The values for the LD_{50}'s are from a variety of sources and have been freely

TABLE III-3

Relative Risks of Alternative Toxicants

LD_{50}	Strychnine (0.5% bait) LD_{50} (mg/kg)	Strychnine (0.5% bait) Relative Risk1/	Compound 1080 (0.075% bait) LD_{50} (mg/kg)	Compound 1080 (0.075% bait) Relative Risk1/	Zinc Phosphide (2.0% bait) LD_{50} (mg/kg	Zinc Phosphide (2.0% bait) Relative Risk1/
Quail	135.0	1.0	4.0, 20.0	5.1, 1.0	13.0	42.0
Pheasant	25.0	1.9	7.0	1.0	18.0	10.0
Duck	5.0	6.7	5.0	1.0	36.0	3.7
Goose	4.0	8.4	5.0	1.0	8.0	17.0
Dove	9.0	8.2	11.0	1.0	34.0	8.6
Blackbird	5.0	3.3	2.5	1.0	24.0	2.7
Sparrow	5.0	4.0	3.0	1.0	-	-
Eagle	5.0	1.7-6.6	1.2, 5.0	1.0	-	-
Ground Squirrel	20.0	1.0	0.35	8.6	33.0	2.4
Prairie Dog	1.5	3.0	0.3	2.3	18.0	1.0
Jackrabbit	4.4	8.4	5.6	1.0	8.2	18.0
Cat	0.75	13.0	0.2	7.4	40.0	1.0
Dog	1.1	9.1	0.06	25.0	40.0	1.0
Kit Fox	0.75	31.0	0.22	16.0	93.0	1.0

1/ The least toxic bait for each animal is arbitrarily assigned a value of 1.0.

rounded and averaged. Each of the table values has been derived from one or more species or tests as appropriate.

Some variation between species in reported LD_{50}'s is apparent. The source of this variation is uncertain and most reported differences have not been considered important for the present purposes of seeking generalizations. Substantial variation in toxic response is reported among quail for compound 1080; the LD_{50} for the California quail is about four mg/kg while that for the Gambel's quail is 20 mg/kg . With limited data, therefore, the accuracy of the values is uncertain and the generalizations to be made cannot apply to any similar species that may be either extremely sensitive or extremely resistant to a particular toxicant.

To obtain the relative risk from the consumption of bait for each species, the LD_{50} values for each toxicant were divided by the concentrations of the toxicant in the bait formulation employed by the USDI. This procedure gives the relative amount of bait that is equitoxic to the species. Assigning an arbitrary value of 1.0 to the least toxic formulation and dividing the relative amount of bait for the formulation by that for an alternative gives the relative toxicity of the alternative[1] . Thus, for pheasant, compound 1080 has the lowest LD_{50} but its dilution (0.075 percent) in the bait makes it the least hazardous, other things being equal. Strychnine is less toxic to pheasants than compound 1080 but its higher concentration in bait makes the bait about twice as toxic to pheasants. Considering the quality of the data and other variables, however, the observed difference between the estimates of the two formulations cannot lead to a conclusion that substantial differences in risk can be anticipated from use in the field.

For zinc phosphide, different estimates of the LD_{50} for pheasant (9-27 mg/kg) range from near that for compound 1080 to several times as great; however, the concentration of "zinc" in the bait gives a relative risk factor of from 7 to 21 and averaging 10. From this analysis, it is reasonable to conclude that the risk to pheasants from the use of zinc phosphide is substantially greater than that for both strychnine and compound 1080.

Allowing for the variable quality of these data, and species variability, Table III-3 indicates some generalizations that are relevant for a comparative risk assessment.

1. For a wide variety of birds, compound 1080 bait is the least hazardous. For gallinaceous birds, zinc is the most hazardous but for waterfowl, doves and blackbirds, zinc and strychnine are about equal.

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[1] Example: Dividing each LD_{50} for the pheasant by the concentration of the bait for each pesticide yields the following: strychnine = 25/0.5 = 50; compound 1080 = 7/0.75 = 93; zinc phosphide = 18/2 = 9. The relative risk for each toxicant is therefore: strychnine = 93/50 = 1.9; compound 1080 = 93/93 = 1.0; zinc phosphide = 93/9 = 10.

2. Responses among rodents and rabbits appear to be more variable and hence less predictable. Zinc phosphide is the most toxic bait for the jackrabbit and the least for the prairie dog (black-tailed). Compound 1080 is the most toxic bait for the ground squirrel (California) and least for the jackrabbit.

3. For carnivores, the risk from zinc phosphide appears to be relatively low although good toxicity data are difficult to obtain because zinc phosphide may induce vomiting in treated animals. The risk of secondary hazard is further reduced by detoxification of zinc phosphide in the stomach of poisoned animals. In general, the risk to carnivores from strychnine and compound 1080 bait do not differ substantially. The most common exposure of carnivores to grain baits is, however, indirect. The greatest hazard from feeding on strychnine-killed animals is associated with the ingestion of unabsorbed poison in the digestive tract. This factor would generally make secondary hazards to carnivores lower for strychnine than those for compound 1080.

4. For raptors (including vultures) comparative data are limited to those on strychnine and compound 1080 for the golden eagle. Because of the problem of indirect exposure to strychnine bait in the digestive system, it is not clear that a substantial difference in secondary risk exists between strychnine and 1080. While no raptor toxicity data for zinc phosphide are available, the detoxification of zinc in the stomach of victims would lead to a prediction of relatively low risk to raptors. Some degree of confidence in this prediction is supported by the observations that (1) compared to strychnine and 1080, the variability of toxic response is low (reported LD_{50} range over two orders of magnitude in strychnine and 1080 and less than an order of magnitude for zinc phosphide) and thus more predictable, and (2) raptors are capable of regurgitating their stomach contents (although not reported for raptors, zinc phosphide may induce regurgitation in carnivores).

Comparative data for anticoagulants are not extensive. Studies using ducks, quail, and blackbirds have suggested very low potential for risk. However, some secondary mortality to raptors has occurred and recent laboratory studies confirm that owls are sensitive to diphacinone poisoning (Mendenhall and Pank, unpublished). Additionally, fatalities to dogs have been associated with the use of diphacinone to control orchard mice and it is apparent that these compounds, which have long been emphasized because of their relative safety to humans, may pose significant risks for raptors and carnivores.

Fumigants will kill most vertebrates inhabiting the treated burrow. The occupants may include black-footed ferrets, burrowing owls, snakes and other species in addition to the target species. No secondary hazards are anticipated from the use of fumigants.

The above observations on apparent relative risk are generally supported by field observation (Hegdal and Gatz 1977, 1977a, 1979). It can be concluded that all rodenticides pose risks of varying degree for nontarget birds and mammals and that the substitution of one toxicant for another may merely shift the risk from one set of nontarget species to another. For instance, substituting zinc phosphide for strychnine may substantially reduce risk to carnivores but would increase risks to gallinaceous birds and not substantially alter the risks for waterfowl, doves, and passerines. The actual magnitude of any effects or changes in effect can not be predicted but the direction of the change in risks from substitute rodenticides can reasonably be anticipated.

Variation in concentrations of the toxicants, acceptability of the bait and other factors influencing exposure must be considered in the assessments. Of substantial concern in this regard is the persistence of toxic bait in the field. Fresh baits (leaves, fruits) and pelletized baits may be expected to lose their attractiveness to birds and mammals rather rapidly when exposed to the environment. Highly persistent poisons would thus not be needed with fresh baits since acceptance would be low. The observation that strychnine-treated oats were still killing doves after more than two months in the field (Hegdal and Gatz 1977), however, is disturbing, since little benefit is likely to be derived from such persistence.

7. Summary

Considering use rates, treatment strategies, toxicity data, and field studies, the following discussion characterizes the relative risks inherent in the use of compound 1080 and strychnine and their alternatives for ground squirrel control on pasture or rangeland.

The risk of strychnine as used in above-ground squirrel control appears to center upon population reduction of small birds, such as songbirds and doves, by direct poisoning of birds eating the bait. Other birds and mammals may also be killed but available field evidence does not demonstrate that this effect is generally substantial.

The risk of compound 1080 appears to center upon carnivorous species such as coyotes or bobcats by way of secondary poisoning. Other unrelated families of wildlife, though susceptible according to toxicological studies, did not appear to suffer significant mortality from current compound 1080 ground squirrel control techniques in California.

Zinc phosphide provides some demonstrable hazard to pheasants and rabbits, but little hazard to other unrelated wildlife species has been established.

The anticoagulants do not appear to have produced any significant nontarget wildlife kills, but do appear to be very selective for rodent-type mammals, and possess ample safety margins for most birds. Some owls and perhaps other untested species are susceptible to secondary poisoning by DPN. Effects of CPN and DPN upon small nontarget wild carnivorous mammals would need investigation prior to conclusions of safety for such mammals.

Fumigants pose no secondary risk to wildlife but will kill most nontarget occupants of treated burrows.

C. Alternatives - Bird Control

The objective in using strychnine baits is to obtain a rapid reduction in a local pest population. Since, when used properly, no other federally registered pesticide can normally achieve this objective for birds, there are no chemical alternatives to strychnine. In managing a pest situation, however, there are alternatives when rapid population reduction is not required. Federally registered pesticides that may provide alternative solutions to specific problems include 4-aminopyridine (avitrol), polyisobutylene, polybutene, mesurol, starlicide, endrin and fenthion, and for pigeons, azacosterol (ornitrol), diphacinone, and pival.

The compound 4-aminopyridine is formulated in baits to function primarily as a repellent. Members of a flock that ingest lethal or near-lethal levels produce distress calls and other behaviors that frighten the remainder of the flock, causing it to disperse from the site to be protected. Direct risks to non-target species are generally low since this is not used as a toxicant and risks from secondary poisoning seem highly unlikely (Clark, 1975, Schafer and Marking, 1975).

Polyisobutylene, polybutene, and mesurol are repellents with no recognizable risk to nontarget species. They are used, respectively, on roosting places on structures and on certain small fruits.

Starlicide is a slow acting toxicant, highly toxic to starlings, less toxic to most other birds, and relatively nontoxic to rats.

Endrin and fenthion are both used in artificial perches placed in roosting areas around structures. Birds landing on the perches many absorb lethal doses through the feet. While, in proper use, nontarget species are unlikely to land on these perches, some potential for secondary risks may be associated with the use of endrin. The Agency has prohibited such use in the vicinity of peregrine falcon aeries.

Azacosterol baits are used to inhibit reproduction in pigeons. No risks to nontarget species are recognized.

In summary, chemicals used in control strategies that do not require a rapid reduction in the pest population pose less of a risk to nontarget species than does strychnine.

D. Summary of Relative Risk by Use Pattern

1. General

The following section presents the Agency's conclusions regarding the risk to nontarget wildlife from the above-ground uses of strychnine and its alternatives. These conclusions reflect a judgment of the available information presented above and reasonable extrapolations. In many cases, it was not possible to conclude that substantial risks would result from the use of strychnine to control specific pests on specific sites providing that proper precautions were taken. These extrapolations take into consideration the fact that site conditions vary substantially, that operator judgment is required, and that label directions and formulations vary. It has long been a policy in the registration of pesticides to require that risks to wildlife be reduced by any appropriate means that would not substantially reduce the benefits of use. Such reasonable precautions are required, independent of the RPAR process.

Where appropriate, the precautions will be considered under regulatory options. In other cases, data are not available for the Agency to determine whether or not substantial risks are likely.

2. Rangeland and Pasture Rodents

a. Prairie Dogs

The use of strychnine may jeopardize the continued existence of the black-footed ferret and cause population reductions in other nontarget species that feed on the bait. Use of the most likely alternative, zinc phosphide, would substantially reduce the possibility of secondary hazards to ferrets and other predators/scavengers that may feed on dead or dying prairie dogs. Direct risks to gallinaceous birds, such as prairie chickens and sharp-tailed grouse, may increase substantially if zinc phosphide is used but specific information on these species is unavailable.

b. Ground Squirrels

The use of strychnine may cause population reductions in various species of birds that feed on the bait. The extent to which dyeing the bait can reduce this risk is uncertain. Use in the vicinity of various endangered species (black-footed ferret, San Joaquin kit fox, California condor, peregrine falcon and others) may result in mortality to individuals. If, in fact, dyeing the bait reduces risks to nontarget avian species, such as doves, indirect risks to endangered species that may feed on those nontarget species would be reduced. Use of the most likely alternative, carbon disulfide, would eliminate all secondary risks to nontarget organisms associated with the use of poisoned baits. Risks to any nontarget occupants of burrows (ferrets, burrowing owls, snakes) would increase substantially over that associated with the use of strychnine in any particular area. Use of compound 1080 (California, Nevada, and Colorado) would probably increase the risk to carnivores (coyote, bobcat) and decrease the risk to birds in general.

c. Miscellaneous Rodents and Lagomorphs

At this time, available evidence does not permit the Agency to conclude that substantial risks to nontarget organisms would generally result from the use of strychnine to meet sporadic needs to control local infestations of various rangeland rodents if proper precautions are taken. Some nontarget mortality would be expected and due concern for any endangered species must be given.

3. Cropland Rodents

a. Prairie Dogs

Risk from strychnine and its alternatives would be generally similar to that for rangeland.

b. Ground Squirrels

Risks from the use of strychnine and its alternatives would be generally similar to those for rangeland. Fresh baits in some situations are likely to be used instead of grain baits, transferring risk to a different subset of nontarget species and perhaps having a lower potential for overall risks.

c. Miscellaneous Rodents and Lagomorphs

At this time, available evidence does not permit the Agency to conclude that substantial risks to nontarget organisms would generally result from the use of strychnine to meet sporadic needs to control local infestations of various cropland rodents if proper precautions are taken. Some nontarget mortality would be expected and due concern for any endangered species must be given.

4. Nonagricultural Sites for Rodents and Lagomorphs

At this time, available evidence does not permit the Agency to conclude that substantial risk to nontarget organisms would generally result from the use of strychnine to control rodents and lagomorphs on nonagricultural sites if proper precautions are taken. Some nontarget mortality can be expected and due concern must be given for any endangered species.

5. Cropland Birds

At the present time, available evidence does not permit the Agency to conclude that the use of strychnine to control birds in California cropland (sprouting seeds, rice, sunflowers, cherries, grapes, feedlots) is likely to have substantial effects on nontarget wildlife. Some direct and indirect nontarget mortality is to be expected and due precautions must be taken to protect endangered species. The same assessment applies to the use of strychnine to control magpies in Nevada and Wyoming.

6. Nonagricultural Sites for Birds

At the present time, available evidence does not permit the Agency to conclude that the use of strychnine to control pigeons and house sparrows on nonagricultural sites is likely to have substantial effects on nontarget wildlife. Some direct and indirect nontarget mortality is to be expected and due precautions must be taken to protect endangered species.

IV. Benefit Analysis

A. Introduction

The Agency has evaluated the potential economic impacts of cancelling strychnine for outdoor above-ground use. The conclusions are based on information from a number of sources, principally the Preliminary Benefit Analysis.[1] In addition, rebuttal comments from registrants, users, and other parties; federal and state vertebrate pest control specialists; and available published data, were considered in the Agency's conclusions.

The Agency's analysis focuses on two general types of pests - birds and rodents (including rodent-like animals) and three broad areas rangeland/pasture, cropland, and nonagricultural sites. Within these general categories, the Agency identified the major and minor uses of strychnine; estimated the quantities used; listed the registered alternatives, including an evaluation of their efficacy and availability; and evaluated the impact upon users and the agricultural sector. The Agency estimated the economic impact which could result if registrations of strychnine for above-ground uses are cancelled and users shift to alternative control materials or strategies. In addition, the Agency evaluated the simultaneous cancellation of sodium monofluoroacetate (compound 1080) on those sites where compound 1080 is used or could be used as a substitute for strychnine.

The Agency faced severe data limitations in this analysis and has had to use considerable judgment in evaluating the potential economic consequences of cancelling the outdoor, above-ground uses of strychnine. The analysis often provides qualitative estimates or discussions of impacts due to the lack of sufficient usage or comparative efficacy data to support precise quantitative estimates. Although estimates in this document are reported as point estimates, they represent rough predictions of strychnine bait distribution and economic impact. The Agency used reasonable assumptions in its estimates to reflect the general economic consequences of cancelling strychnine usage.

In general, the economic impacts of cancelling the outdoor, above-ground uses of strychnine would not significantly affect U.S. production or prices of major commodities or services. Impacts on agricultural productivity and production costs would generally be limited to users in western states. Regional or local impacts to users are indicated where no registered alternatives exist or where registered alternatives are more costly, impractical, or ineffective.

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[1] Prepared under contract by Development Planning and Research Associates, Manhattan, Kansas. EPA Contract No. 68-01-4339. 1979. See Appendix E.

Unless otherwise noted, the sources for this chapter will be Appendix E.

B. General Production and Use Patterns

Approximately 90.1 percent (449,200 pounds) of the estimated 498,700 pounds of strychnine baits [2] used annually (average for 1977-78) are for control of rodent or lagomorphs (e.g., rabbits) in western states (Table IV-1). Range/pasture and cropland usage for rodent or lagomorph control comprise about 45.6 percent (227,400 pounds) and 42.1 percent, (209,900 pounds) respectively, of annual strychnine bait usage. An estimated 9.9 percent, or 49,500 pounds of strychnine baits are used annually for bird control -- 3.6 percent (18,000 pounds of bait) in cropland and 6.3 percent (31,500 pounds of bait) in nonagricultural sites. The remaining 2.4 percent (11,900 pounds of bait) of annual strychnine bait usage is in nonagricultural sites, primarily for control of commensal rodents.

C. Analysis of Benefits of Strychnine Use on Rangeland/Pasture

Strychnine is federally registered for use in the control of such rangeland rodents as ground squirrels (many species), prairie dogs, cotton rats, kangaroo rats and jackrabbits. Federally registered alternatives for ground squirrels include gas cartridges, carbon disulfide, Thiram, and carbon tetrachloride (under RPAR review). Anticoagulants, methyl bromide, zinc phosphide, and compound 1080 are registered in some states for ground squirrel control. Zinc phosphide is federally registered for the control of prairie dogs, cotton rats, field and meadow mice, and kangaroo rats. For the control of jackrabbits, the repellants Thiram and Hinder are federally registered and the anticoagulants are state registered in California. Table IV-2 lists the chemical alternatives to strychnine with their registrations by site and pest.

1. Ground Squirrels

In North America, there are 22 recognized species of ground squirrels. Some species contain as many as 14 subspecies or races which are distinguished not only by morphological characteristics or distribution characters, but by behavioral differences and varying ecological strategies as well. These latter characteristics frequently affect the efficacy of various control methods.

Currently, six ground squirrel species are of sufficient economic importance to justify regular control efforts: Richardson's ground squirrel, California ground squirrel, Columbian ground squirrel, Belding's ground squirrel, Townsend's ground squirrel, and Uinta ground squirrel. Other species which occasionally require control include the antelope ground squirrel, thirteen-lined ground squirrel, round-tailed ground squirrel, golden-mantled ground squirrel, and rock squirrel. Columbian, Uinta, and Townsend's ground squirrels have increased in numbers during recent years, and demands for control efforts are increasing.

2/ Outdoor above-ground usage only.

Table IV-1

Estimated Annual Above-Ground Usage of Strychnine
Bait for Rodent and Bird Control, 1977-78

Pest	Range/ Pasture		Cropland		Other		Total	
	(lbs)	(%)	(lbs)	(%)	(lbs)	(%)	(lbs)	(%)
Rodents	227,400	45.6	209,900	42.1	11,900	2.4	449,200	90.1
Birds	--	--	18,000	3.6	31,500	6.3	49,500	9.9
Total	227,400	45.6	227,900	45.7	43,400	8.7	498,700	100.0

SOURCE: Development Planning and Research Associates, 1979.

Table IV-2

Chemical Alternatives to Strychnine for Rodent and Lagomorph Control

	Pest													
	Ground Squirrels	Marmots/ Wood-chucks	Porcu-pines	Prairie dogs	Jack Rabbits	Rabbits	Kanga-roo rats	Cotton rats	Chip-munks	Deer Mice	Meadow Mice	Opossum	Mountain Beavers	House mice
Acute Toxics														
1080 1/	Nv., Ca., Co.			Co.			Nv.	Ca., Nv.	Nv.	Ca.	Ca.			F
Zinc phosphide	Ca., Nv., Or.			F			Ca.	F		F	F			F
Endrin											F			
Repellents														
Hinder					F	F								
Thiram	F					F			F		F			
Fumigants														
Gas cartridges	F	F		F										
Carbon disulfide	F													
Methyl bromide	Ca., Nv.													
Calcium cyanide		F												F
Carbon tetra-chloride 1/ 5/	F													F
Anti-coagulants	2/									2/	2/			
Pival	Ca.					Ca.								
Fumarin					Ca.									F
Diphacinone	4/				Ca.					3/	3/			F
Chlorophacinone	Ca., Id.				Ca.			Fl.		Or.,Ca.	Fl.,Or.			F
Warfarin	Ca.				Ca.									F
PMP														F
Talon														F
Maki														FRP

1/ RPAR Chemical

2/ For ground squirrel and orchard mice control, most states have one or more anticoagulants registered under Section 24(c) of FIFRA (special local need).

3/ State registrations for Ca., Co., Id., Mi., Nc., Ny., Oh., Or., Pa., Ut., Va., Wa.

4/ State registration for Az., Ca., Co., Id., Mt., Nm., Nv., Or., Ut., Wa., Wy

5/ Formulated with paradichlorobenzene and ethylene dichloride

F: Federally Registered
FRP: Federal Registration Pending

In range and pasture lands, ground squirrel foraging reduces the amount of plant material available to grazing livestock. In addition to forage consumed, ground squirrels eliminate vegetation by clearing and tramping areas near burrows and runways. Ground squirrels will invade cropland and reduce yields in alfalfa, small grains and a variety of fruit and nut crops. Losses are particularly significant in fields bordered by infested rangeland or infested woodland. Crop losses of 10 to 30 percent are common while some small fields (i.e. 10 to 50 acres) can be almost completely destroyed. In addition, damage to harvest and other farm machinery, caused when the equipment runs into or over burrows, can be quite substantial.

If strychnine were cancelled for ground squirrel control in rangeland, the only registered alternative available in all states is fumigation with either carbon disulfide, gas cartridges, or carbon tetrachloride. While these materials can be used effectively, their usage has historically been confined to relatively limited areas due to labor requirements and high costs, ranging from about $12 to $17 per acre compared to about $2.35 per acre for strychnine. Currently an estimated 233,110 acres or about 0.02 percent of the grazing acreage in the 48 contiguous states are treated annually with strychnine for ground squirrel control at a cost of about $543,000. If strychnine were cancelled and compound 1080 were to be available (currently registered in three states) user control costs would increase by about $900,000 annually. If compound 1080 is not available, annual control costs would total about $2.1 million, an increase of nearly $1.5 million. Most likely these increased costs would be absorbed by users or publicly supported rodent control programs rather than passed along to consumers. The annual increased rodent control cost on individual ranch operations, while extremely variable, is estimated to average about $320, which represents annual production cost increases of about 4 percent on smaller ranches and about 0.5 percent on larger ones. Expenditures for rangeland rodent control are extremely minor when compared with other production costs such as veterinary expenses and feed costs. Also, only a minute amount of the grazing land is treated with strychnine. Consequently, the impact of cancelling strychnine use on rangeland for control of ground squirrels would be generally limited to affected individuals but should have no appreciable effects on livestock markets or consumer meat prices.

2. Prairie Dogs

Prairie dog numbers and density decreased greatly between 1930 and 1973. However, in recent years the area occupied by prairie dogs has increased from an estimated 1.3 million acres in 1973 to 2.1 million acres in 1979 (Table IV-3). Black-tailed prairie dogs, occurring in approximately 59 percent of this acreage, are the major pest species.

Approximately 88,000 pounds of strychnine baits are used to treat an estimated 96,000 acres of range and pasture for prairie dog control. Zinc phosphide, the most likely alternative if strychnine use were cancelled, is slightly less expensive (approximately $0.25/acre less) than strychnine and is about equally effective. The use of zinc phosphide

Table IV-3

Estimated U.S. Acreage of Range and Pasture Infested with Prairie Dogs

State	All Prairie Dogs		Black-tailed Prairie Dog
	1973	1979	1979
N. Dakota	8,000	11,000	11,000
S. Dakota	60,000	300,000	300,000
Nebraska	15,000	55,500	55,500
Kansas	36,000	60,000	60,000
Oklahoma	15,000	20,000	20,000
Texas	77,500	90,000	90,000
New Mexico	248,000	300,000	200,000
Arizona	2,000	5,000	---
Colorado	417,000	500,000	100,000
Montana	132,000	309,500	232,000
Wyoming	178,500	300,000	200,000
Utah	68,000	190,000	---
Total	1,257,000	2,141,000	1,268,500
	1961	1965	
	1,715,000	1,668,000	
	1968	1971	
	1,621,000	1,574,000	

Source: Development Planning and Research Associates, 1979 could reduce total control costs by about $24,000 annually. Therefore, a shift from strychnine to zinc phosphide would create slight savings to the user and would have no consumer or commodity market impacts.

3. Other Rodents and Lagomorphs

Considering the number of the rodents and lagomorphs, only a small group adversely affect rangeland under modern management. In local situations some species of kangaroo rats, cotton rats, meadow mice, and jackrabbits can become problems requiring control efforts. Strychnine is federally registered for control of kangaroo rats, cotton rats, meadow mice and jackrabbits (Table IV-2). An estimated 4,500 pounds of strychnine baits are used annually for control of these pests (less than one percent of total strychnine usage). Alternatives are quite limited. Only zinc phosphide and Thiram are federally registered for control of cotton rats and meadow mice. The repellants are federally registered and anticoagulants are available in California for jackrabbit control.

If strychnine were to be cancelled, losses on rangeland would increase during periods of high population outbreaks, since no toxicants are registered to replace strychnine in many states. However, since the estimated usage of strychnine for control of these pests is relatively small, impacts would most likely be limited to local user-level effects and would not be expected to appreciably affect livestock markets or consumer meat prices.

D. Analysis of Benefits of Strychnine Use on Cropland

An estimated 210,000 pounds of strychnine baits are used on about 254,000 acres of cropland annually to control depredation by ground squirrels, prairie dogs and other rodents. About 91 percent of the bait (191,100 pounds) is used for ground squirrel control on about 240,000 acres; seven percent of the bait (14,310 pounds) is used for prairie dog control on 14,310 acres; and two percent of the bait (4,500 pounds) is used for miscellaneous rodent control. In descending order, Nevada, Montana, California, and Idaho were the largest users of strychnine bait for rodent control in cropland.

The six species of ground squirrels identified as economically important in rangeland damage and the black-tailed prairie dog are also the rodents most often involved in damaging cropland.

1. Prairie Dogs

An estimated 14,300 pounds of strychnine baits are used annually to control prairie dogs on about 14,300 acres of cropland (Table IV-4).

If strychnine were to be cancelled for prairie dog control in cropland, the most likely federally-registered alternative would be gas cartridges. Zinc phosphide is not registered for use on cropland. Gas cartridges are more expensive than strychnine and would result in increased costs to users of about $14 to $19 per acre or about $206,300 to $270,900 annually, if used on all acres currently treated with strychnine.

Table IV-4

Estimated Acreages of Cropland Treated with Strychnine for Prairie Dogs and Ground Squirrels, 1978

Region and State	Prairie dogs 1/	Ground squirrels 2/
Northern Plains:	1,800	23,214
North Dakota	0	742
South Dakota	1,460	5,500
Nebraska	340	11,692
Kansas	0	5,280
Southern Plains:	3,125	978
Oklahoma	0	0
Texas	3,125	978
Mountain:	9,385	142,040
Montana	0	72,007
Idaho	0	33,957
Wyoming	2,640	6,383
Colorado	0	6,200
New Mexico	6,445	1,807
Arizona	0	0
Utah	300	3,353
Nevada	0	18,333 3/
Pacific:	0	73,692
Washington	0	4,875
Oregon	0	25,155
California	0	43,662 4/
TOTAL	14,310	239,923

1/ Pounds of bait from Table IV-2 : 1 pound of bait per acre application rate (Henderson, 1979).

2/ Pounds of bait from Table IV-2 : 0.6 pounds of bait per acre application rate (Clark, 1975) unless noted otherwise.

3/ 55,000 pounds of cabbage bait used mostly at 1-3 pounds per acre (Rowe, 1979). It was assumed that 3 pounds per acre were applied.

4/ Includes 43,262 acres that were treated with grain bait at an assumed rate of 0.6 lbs/acre and 400 acres that were treated with cabbage bait applied by hand at the rate of 10 lbs/acre (Sauer, 1976; O'Brien, 1978).

No macroeconomic impacts would be anticipated if strychnine were cancelled for prairie dog control. The impact, while important in individual cases at the user level, would, in the aggregate, be too small to result in macroeconomic impacts.

2. Ground Squirrels

About 240,000 acres of cropland are treated annually with an estimated 191,000 pounds of strychnine bait to control ground squirrels. The mountain states (Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah and Nevada) use 67 percent of the strychnine bait to control ground squirrels on cropland, and the Pacific states (Washington, Oregon and California) use 25 percent. Together these two areas account for nearly 92 percent of the strychnine baits used to control ground squirrels on croplands.

The most likely alternatives to strychnine, depending on available registrations and ground squirrel species, include diphacinone, compound 1080, zinc phosphide and carbon disulfide. If strychnine were cancelled and compound 1080 were available, producer control costs could increase by a minimum of $5.80 per acre or $1.4 million annually. Without compound 1080, producer control costs could increase about $1.6 million annually or $6.60 per acre.

No macroeconomic impacts would be anticipated as a result of cancellation of strychnine for above-ground rodent control on cropland. The impact, while important in individual cases would be, in the aggregate, too small to result in macroeconomic impacts.

3. Other Rodents and Lagomorphs

Complete data on strychnine bait usage to protect cropland from rodent and rabbit damage are not available. In local situations, field and meadow mice and jackrabbits can become problems, particularly during periods of high population outbreaks. Since no registered alternatives are available in many states for control of particular pests, cropland losses will increase when and where such pest outbreaks occur. Since only a small amount of strychnine bait is used annually for control of these pests, impacts would most likely be limited to the user level effects and should not appreciably affect major crop markets or consumer prices.

E. Analysis of Benefits for Strychnine Use on Cropland for Bird Control

All Federal registration of strychnine for bird control are for use on nonagricultural sites. However, a variety of strychnine products are state-registered in California, Nevada, and Wyoming for control of bird depredation in croplands. The Agency's analysis is limited to California since Nevada and Wyoming registrations are for magpie control only and sufficient data were not available for analysis of this pest situation.

Approximately 18,250 pounds of strychnine bait are used to kill birds on an estimated 36,500 acres of California croplands. No consistent and reliable data are available to estimate the use of strychnine-treated baits by individual crop. However, principal crops damaged include grapes, cherries, sugar beets, lettuce, nuts, vegetables, rice and other small grains, tomatoes, plums and melons. In general, strychnine bait is distributed across crop groups as follows: 45 percent on vegetables and melons, or 16,400 acres; 35 percent on fruits and nuts,or 12,800 acres; and 20 percent on field crops, or 7,300 acres.

If strychnine were cancelled for this use, the most likely alternatives include repellants (on selected sites), mechanical and electronic devices, trapping, shooting, and habitat manipulation. However, these alternatives do not provide the toxic control presently available only through the use of strychnine. No alternative toxicants are federally registered for bird control in cropland, although starlicide is federally registered for use on feedlots.

Since no alternative chemical toxicants are available for control of bird depredation in cropland, and since strychnine is used only where bird damage occurs, producers who currently use strychnine to control depredation would likely suffer increased losses if strychnine were cancelled. Quantitative data to estimate the extent and value of bird depredation are generally lacking, spotty or incomplete. Quantitative analysis is further complicated by the wide diversity of bird species which damage a wide variety of crops. Many crops can suffer losses ranging from about 5 to 20 percent of yield on treated acreage. Individual acreages of specific crops can be completely destroyed. However, comprehensive infestation and damage estimates for the cropland acres currently treated with strychnine are not available.

If strychnine were cancelled for control of birds on cropland, the incremental loss would occur only on those acres where strychnine is now used. Thus, the incremental loss would be confined to the total area now treated, about 36,500 acres. In California, this could result in crop losses estimated at $1.5 million annually.

The estimated 36,500 acres currently treated represent about 0.4% of the total acreage of fruits, nuts, vegetables, melon and field crop produced in California. Clearly, the use of strychnine is of minor importance to the total California cropland picture which totals $5.5 to $6.0 billion on about 9.1 million acres annually. Thus, while individual producers may be seriously affected, the U.S. supply and price of fruits, nuts, vegetables and field crops would be largely unaffected by cancelling strychnine for bird control in cropland.

F. Analysis of Benefits of Strychnine Use on Nonagricultural Sites

1. Birds

Strychnine is federally registered for outdoor use in the control of pigeons and house sparrows on structures, vacant lots, and roosting places. Pigeon control uses account for more than 98 percent of the estimated 31,500 pounds of strychnine baits used annually for pigeon and sparrow control.

Alternatives include 4-aminopyridine (Avitrol), polyisobutylene, polybutene, azacosterol, endrin, and fenthion (Table IV-5). Mechanical means such as traps, frightening devices and structural changes designed to eliminate roosting and nesting places are also useful.

In assessing the costs involved in a bird control program it is important to consider the time required for a comparable level of control in addition to the costs of materials and costs of application. Thus the particular situation and the reason for desiring to reduce or eliminate the pest birds and the time required for a specific control method are factors, especially when potential health problems are indicated.

The costs involved in structural changes in buildings to eliminate or screen roosting or nesting places are site-specific and usually more expensive than chemical control, although they may represent a more satisfactory long term solution to pigeon or house sparrow problems at that site.

Mechanical methods may ultimately offer essentially the same level of reduction of bird populations as strychnine. They are, however, much more labor intensive and thus more expensive and require a longer period of time. For the satisfactory management of any pest species, the integration of structural repair and improved sanitation, as well as repellants and toxicants, is required.

The major impact resulting from the cancellation of strychnine for outdoor control of pigeons and sparrows would be the elimination of a very quick-acting tool when public health is an issue. The pigeon and the house sparrow have been implicated in the spread of many human diseases such as, ornithosis, salmonellosis, cryptococcosis, Newcastle disease, histoplasmosis and encephalitis. Birds have been implicated in the spread of livestock diseases such as transmissible gastroenteritis (TGE). Pigeons and house sparrows that form large concentrations and roost near human habitations can increase the chances for the spread of histoplasmosis, a fungus that can grow in accumulation of bird droppings. The direct impacts from cancellation of strychnine for pigeon and sparrow control on nonagricultural sites are unknown. In the aggregate, no significant consumer impacts would be expected since some alternatives are available. However, there could be potentially serious impacts in local areas due to the inability to quickly control pigeons and sparrows.

Table IV-5

Chemical Alternatives to Strychnine for Bird Control

Pest	Site	4-amino-pyridine	Star-licide	Polyiso-butylene & polybutene	Aza-costerol	Fenthion	Mesurol	Endrin	Diphacinone	Pival
Pigeons	Structure roost	F	Ca.	F	F	F		F	Ca.	Ca.
House sparrows	Structure roost	F		F		F		F		
Crowned sparrows	Sprouting crops	Ca.								
Blackbirds	Structure roosts	F								
	Sprouting crops	Ca.								
	Feedlots 1/	F	F							
Starlings	Structure roosts	F		F		F		F		
	Feedlots	F								
Starlings, blackbirds, sparrows	Cherries						F			
House finches (linnet)	Grapes	Ca.								
Horned larks	Sprouting crops	Ca.								
Cowbirds	Structure roost	F								
Magpies	Crops									
Meadowlark	Sprouting crops									
Crows	Roosts	F								
Blue jays	Cherries						F			

F: Federal Registration

1/ Strychine registered for this use only in California.

2. Rodents and Lagomorphs

Strychnine is registered for use in the control of ground squirrels, prairie dogs, cotton rats, kangaroo rats, deer mice, meadow mice, chipmunks, house mice, porcupines, jackrabbits, marmots/woodchucks, mountain beavers, opossums, and rabbits on nonagricultural sites. For purposes of this analysis, nonagricultural sites have been defined as areas which are not involved in the direct production of crops or livestock. They include structures, premises, embankments, nonagricultural turf areas and private forest areas (Table IV-6).

Very little data are available to estimate the overall use of strychnine on these sites. Most of the strychnine use on nonagricultural sites appears to be for below-ground control of pocket gophers and moles in turf. These uses are not part of this RPAR. Lesser quantities are used indoors (Non-RPAR) to control house mice. Most of the outdoor, above-ground strychnine use is restricted to ground squirrel treatments on embankments and turf areas and control of porcupines.

Federally registered alternatives for rats and mice include compound 1080, zinc phosphide, diphacinone, chlorophacinone, warfarin, carbon disulfide and methyl bromide. Zinc phosphide is federally registered for control of cotton rats and kangaroo rats. For ground squirrel control, federally registered alternatives include gas cartridges and carbon disulfide. Compound 1080, zinc phosphide, diphacinone, methyl bromide, Warfarin, Fumarin, Pival, and chlorophacinone are registered in some states for ground squirrel control.

If strychnine were to be cancelled for use on nonagricultural sites, some increased incidences of ditch bank, levee, and canal washouts are likely, particularly if compound 1080 were also to be cancelled. Each incidence of major failure of a canal, levee, or ditch bank can cost in excess of $10,000 to repair. The estimated total increased incidence of this damage is not known however. No other significant user impacts are anticipated if above-ground, outdoor uses of strychnine for control of rodents on nonagricultural sites are cancelled.

Table IV-6
Major Pests on Nonagricultural Sites Controlled With Strychnine

Nonagricultural Sites	Major Target Pests (outdoor, above ground)
Structures, Premises and Related Sites [1]	
Grain elevators	House mice
Other crop storage areas and facilities	House mice
Commercial buildings and warehouses	House mice
Farmsteads	House mice
Urban dwellings	House mice
Embankments	
Ditch banks	Ground squirrels
Levees	Ground squirrels
Dikes	Ground squirrels
Canals	Ground squirrels
Earthen dams (small)	Ground squirrels
Nonagricultural Turf Areas	
Golf courses	Ground squirrels
Parks	Ground squirrels
Cemetaries	Ground squirrels
Athletic fields	Ground squirrels
Recreational areas	Ground squirrels
Airport turf runways	Ground squirrels
Military bases	Ground squirrels
Forest Areas (privately owned)	
Tree nursery	Ground squirrels, rabbits
Tree plantations	Ground squirrels, porcupines, rabbits
Reforestation areas	Ground squirrels, porcupines

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[1] The strychnine RPAR applies only to outdoor, above-ground uses. Thus, strychnine is assumed to be registered for use inside structures and related sites.

V. Risk/Benefit Analysis and Regulatory Options

A. General

The previous two sections have examined the risks and benefits of using strychnine for the control of mammals and birds on rangeland and pasture sites, croplands, and nonagricultural sites. The purpose of this chapter is to compare the risks and benefits for each use, and to evaluate possible regulatory options. Since the risk and benefit data do not always allow for specific site/pest analysis (e.g. jackrabbits on cropland, linnets on cherries), the evaluation will, for the most part, be presented in general terms.

Certain points are important in the risk/benefit evaluation. These form the key issues in developing the actions which might be taken:

1. Actions to be taken are determined by the existence of risks, not the absence of benefits.
2. The use of a substitute must not increase the risks relative to the benefits.
3. Risk mitigating and risk reducing measures must be economically feasible and viable.

B. Risk/Benefit Analysis

1. Rangeland Rodents

The use of strychnine for the control of ground squirrels, prairie dogs and other rodents and lagomorphs on rangeland and pastures presents a risk to nontarget birds and mammals, both from primary and secondary poisoning. The Hegdal and Gatz study demonstrated the risk of primary poisoning by documenting the kill of the majority of the territorial horned larks as well as a number of other birds in a ground squirrel treatment area. Also, the LD_{50} data presented in Section III demonstrated the potential for nontarget seedeating wildlife to ingest a lethal dose of treated grain.

The secondary risks associated with controlling ground squirrels appear to be slight. The relatively high LD_{50} of the ground squirrel suggests that little strychnine would generally remain in the gut for ingestion by a predator. The relatively low LD_{50} of the prairie dog, however, suggests that for this mammal the possibility of secondary risks to nontarget species does exist. The black-footed ferret, an endangered species that lives with and feeds on the prairie dog, would be especially susceptible.

The risks of controlling other rodents and lagomorphs are similar to those for ground squirrels and prairie dogs. The difference is one of degree, since less than one percent of the strychnine bait used annually is for controlling mammals other than ground squirrels and prairie dogs.

No comprehensive estimates are available to document rangeland and pasture damage caused by rodents and lagomorphs. Damage estimates, although largely unsubstantiated, generally provide an indication that a pest problem does exist and that control is believed to be required.

For ground squirrel control, the increased costs from using alternatives could range from $900,000 to $1.5 million annually, depending on the availability of compound 1080 (currently used in two states). For prairie dog control, the use of the zinc phosphide, the most likely alternative, could result in a slight cost reduction. Due to data limitations, estimates for other rodents and lagomorphs are not available.

Strychnine is not used extensively for rodent and lagomorph control on rangeland. Although this use accounts for approximately 45 percent of the strychnine bait used, approximately 0.02 percent of the grazing acreage in the 48 contiguous States is treated annually for ground squirrels and less than 0.01 percent is treated for prairie dogs.

The alternatives for ground squirrel control are few. Only fumigants are federally registered and they are generally used only for spot controls. Zinc phosphide is available for prairie dogs. As shown in the risk analysis, the available alternatives for rangeland rodent and lagomorph control all present a direct risk to nontarget wildlife, but, with the exception of compound 1080 (registered in three states) and possibly DPN, do not present a risk of secondary poisoning as does strychnine.

Although the geographical extent of the risks and benefits are limited, they may be locally significant. The risks are of particular importance when the nontarget wildlife includes one or more endangered species. The following is a listing of the endangered species potentially at risk for each rangeland use:

o pest - ground squirrel
o endangered species - Utah prairie dog, California condor, black-footed ferret, San Joaquin kit fox, gray wolf, grizzly bear, Aleutian Canada goose, peregrine falcon

o pest - prairie dog
o endangered species - black-footed ferret, gray wolf, grizzly bear

o pest - kangaroo rat
o endangered species - Utah prairie dog, masked bobwhite, San Joaquin kit fox

o pest - cotton rat
o endangered species - red wolf, dusky seaside sparrow, Cape Sable sparrow, Mississippi sandhill crane, Attwater's greater prairie chicken, black-footed ferret

- pest - jackrabbit
- endangered species - Utah prairie dog, San Joaquin kit fox, Morro Bay kangaroo rat, red wolf, masked bobwhite, Attwater's greater prairie chicken, black-footed ferret

With the exception of the Aleutian Canada goose and the peregrine falcon, both the USDI and the Agency believe the above ground use of strychnine, as presently registered, is likely to jeopordize the continued existence of the endangered species listed above. The Agency believes this same risk applies to the goose and the falcon.

No above ground rangeland uses of strychnine are known to occur in the ranges of the salt marsh harvest mouse, the masked bobwhite, the California condor, the Morro Bay kangaroo rat, the red wolf, the gray wolf, the grizzly bear, the dusky seaside sparrow, or the Cape Sable sparrow. In the case of an endangered species, however, the Agency believes the potential for exposure is sufficient basis for concern. The benefits of use in their ranges are apparently negligible since strychnine is not currently being used.

Although strychnine may be used in the range of the Utah prairie dog for rodent and lagomorph control, less than one percent of the strychnine bait is used in Utah.

The winter range of the Aleutian Canada goose overlaps that of the California ground squirrel. Most ground squirrel control in California is accomplished with compound 1080, however, and the winter residence time of the goose in California does not generally coincide with the time of ground squirrel baiting.

The use of strychnine in the range of the black-footed ferret is relatively extensive, since it may be found wherever prairie dogs exist. Strychnine may also be used in the range of the San Joaquin kit fox for ground squirrel and/or jackrabbit control.

2. Cropland Rodents

The risks of using strychnine for the control of rodents and lagomorphs on cropland are the same as those for use on rangeland. The amount of bait used is essentially equal (227,400 lbs. for rangeland vs. 209,900 lbs. for cropland).

As with rangeland use, the benefits are stated in terms of the cost differential of using an alternative should strychnine be cancelled. For ground squirrel control, the cost would increase by an estimated $1.4 to $1.6 million annually. For prairie dog control, the cost could increase by an estimated $290,000 if fumigants were to be used. Due to data limitations, estimates for the control of other rodents and lagomorphs are not available.

The endangered species potentially at risk from the above ground use of strychnine for the control of rodents and lagomorphs on croplands are the same as those at risk from rangeland use.

3. Nonagricultural Site Rodents and Lagomorphs

No specific risk data were available for this use. A reasonable assumption, however, is that a risk to nontarget organisms does exist. In particular, all of the endangered species mentioned under the preceeding rangeland and cropland mammal categories could potentially be exposed to strychnine bait. Additionally, the salt marsh harvest mouse, yellow-shouldered blackbird, and Puerto Rico plain pigeon could be exposed, although no strychnine uses are known to occur in their ranges. This potential for exposure is a result of the wide range of site/pest uses in this category.

No benefit data are available, other than for the use of ground squirrel control on canals, levees, and ditch banks. Each canal, levee, or ditch bank failure can result in repairs costing at least $10,000, but the total cost of all repairs is not known. Also unknown is the increase in the number of repairs that could be anticipated should strychnine registration be cancelled.

4. Cropland Birds

Use of strychnine to control birds on croplands accounts for approximately 3.6 percent of strychnine use. Only three State registrations exist for this use, and two are for magpie control only. California accounts for virtually the entire usage of strychnine for the control of bird depredation on cropland.

No specific information is available on the risks associated with these uses. A reasonable assumption, however, is that some primary and secondary risks to nontarget species do exist. The Agency does not believe any endangered species are at risk from the use of strychnine to control cropland birds.

Benefit data are limited to California, and are not available for all individual crops. Only an estimated 0.4 percent of the total cropland in California is treated with strychnine for control of birds. Crop losses, if strychnine were to be cancelled and no alternative were used, could increase by an estimated $1.5 million annually. As stated in Section IV, the total California cropland production is valued at an estimated $5.5 to $6.0 billion annually.

5. Nonagricultural Site Birds

Approximately 6.2 percent of the strychnine bait is used to control pigeons and house sparrows on nonagricultural sites. Virtually all of this bait is used for pigeon control.

No specific risk information is available for this use with the important exception of a risk to raptors. A reasonable assumption, as with all uses of a toxicant such as strychnine, is that a risk to nontarget species does exist. The data on raptor kills are evidence of a risk to the peregrine falcon. Also, although no uses of strychnine are known to occur in Puerto Rico, the yellow-shouldered blackbird and the Puerto Rican plain pigeon could be at risk from this use.

Benefit information is similarly lacking for this use. Other chemicals are available, but they do not provide the fast-acting control believed to be necessary for public health protection.

C. Regulatory Options

1. Rangeland Rodents - ground squirrels

Option - No Action

With this option, the potential for risks to nontargets, including certain endangered species, would continue unabated. The benefits would be similarly unaltered.

Option - Cancellation

Adoption of this option would eliminate the risks of the use of strychnine for ground squirrel control on rangeland and pastures. The lack of economically feasible alternatives could produce a locally significant increase in control costs. Also, the risks of control would not be completely eliminated, since compound 1080 and fumigants, the most likely alternatives, have risks associated with their use. The risk of secondary poisoning would be eliminated if fumigants are used, but the risk of direct effects to nontarget species would still exist. Also, an increase in the use of fumigants could result in an increase in human risks.

Option - Modification of the Terms and Conditions of Registration

The general conclusion of the risk assessment for most uses of strychnine was that available evidence did not now permit the Agency to conclude that substantial risks to nontarget wildlife would generally occur if proper precautions are taken and if due concern is given to protect endangered species. Some nontarget mortality is to be expected from all uses. Certain use modifications, however, could reduce the risks to an acceptable level. These risk reduction measures must not reduce usage to the point of eliminating the benefits, since this would result in an implicit cancellation.

In addition to the use of dyed bait, discussed in Section II, other general procedures may be appropriate for reducing risks from the use of strychnine in vertebrate pest management. General reductions of risks are possible through changes in the characteristics of the bait formulations and the procedures for use. For the protection of endangered species, the major methods of risk reduction are changes in where and when a bait can be used. The following discussion elaborates on these methods.

Bait Formulations

A wide variety of strychnine bait formulations are in use and it seems apparent that the balance between efficacy and safety can be improved. The characteristics of the bait formulations that can be manipulated include the concentration of the toxicant, the attractiveness of the bait to nontarget species, and the persistence of the bait. The following discussion illustrates the problems and potential solutions.

A common formulation for pigeon control contains 0.6 percent strychnine on whole corn. Since the LD_{50} for the pigeon is about 15 mg/kg, ingestion of about two g bait per bird should give adequate efficacy (Faulkner, 1964 estimates that six kernels are adequate). With proper prebaiting, a hungry pigeon may quickly ingest one ounce or more bait (30 g). A substantial reduction in the concentration of strychnine in the bait could probably be made with no loss of efficacy. The observations of Hegdal and Gatz (1977) indicate that the level of strychnine in poisoned doves decreased with the concentration of strychnine remaining on the bait. It seems probable, therefore, that risks can be reduced by altering bait formulations but the lowest level of strychnine that will maintain adequate efficacy must be determined.

As discussed in Section II, several rebuttals of the Agency's presumption of risk indicated that dyeing the bait inhibited its consumption by birds. From the available evidence, the Agency could not conclude that the efficacy of this procedure had been established. In principle, however, making the bait less attractive to nontarget species has much merit. Further development of this concept is desirable.

If a resident target individual is not killed by strychnine the first time it consumes the bait, it is less likely to be killed by subsequent feeding because of bait aversion. In general, persistence of acutely toxic baits beyond the first few days of exposure does not contribute significantly to the success of the control effort but, as indicated by the observations of Hegdal and Gatz (1977a), nontarget immigrants or transients may continue to suffer mortality. A bait that could remain relatively stable for a few days and then rapidly lose its toxic properties could serve to reduce risks that occur after the control operation is effectively complete.

Application Procedures

During a control effort, factors which may alter the risk to nontarget organisms include the application rate, the frequency of application and the method of distributing bait (broadcast vs. spot treatment with or without prebaiting). These variables are largely under the control of the operator and involve decisions that affect efficacy, efficiency and other cost/benefit considerations. These are important components of the management strategy.

Assuming that population reduction is necessary, if just the right amount of suitable bait could be placed so that at the economic threshold, every individual in the target population was likely to be killed with little or no bait remaining, the risks would be minimized and the benefits, in terms of long-term damage reduction, would be maximized. There are practical limitations to achieving such a goal but improvement over the present situation with regard to various uses of strychnine is desirable.

The Agency has no present legal or factual basis to prescribe general curatives for risk situations that result from less than optimal management decisions to use strychnine in accordance with the label. The development and use of management systems that minimize risks, however, would tend to forestall any future findings of unreasonable adverse effects from the use of strychnine and other vertebrate toxicants.

Temporal Restrictions

Some populations of endangered species are migratory; hence, individuals are at risk from the use of strychnine only during the time of year when use coincides with their presence. For example, Arctic peregrine falcons may be present in any of the 48 contiguous states during the period of migration - generally from mid-March through April and from mid-September through October. If uses of strychnine that would lead to the presence of poisoned birds were prohibited during those periods, risks to this peregrine falcon would be substantially reduced in areas that do not support a breeding population.

Geographic Restrictions

Many endangered species have highly restricted distributions. Prohibiting the use of strychnine within the areas likely to be occupied - with an added buffer zone if necessary - could effectively eliminate the potential for exposure. The scale of the restriction, whether micro- or macrogeographic, would vary with circumstances concerning the predictability of the species' presence and needs to prevent disclosure of the locations of individuals.

Thus, the Agency believes four general risk reduction measures have the potential for reducing risks without affecting the benefits. These are: 1) a reduction of the concentration of the active ingredient in the bait, 2) standardization of bait and post-baiting procedures to protect nontarget species, 3) use of dyed baits to repel nontarget seedeaters, and 4) a prohibition of use of the pesticide where or when a significant potential exists for exposure to endangered species.

A fifth measure, integrated pest management (IPM), was investigated as a possible risk reduction method. The goal of IPM is to reduce, if not eliminate, the dependency on chemicals and still achieve the degree of pest control believed to be necessary. This could be through habitat manipulation, introduction of another species (e.g. a predator), and/or an optimal use of the chemical. The optimal use of a chemical requires exposing the target species to the amount necessary to be fatal, at the time when it is most likely to ingest the bait. This would minimize the bait exposure to nontarget species.

The application of possible IPM methods as substitutes or risk reduction measures was discussed with authorities within the Agency, the environmental community, and private enterprises. All believed that this was a desirable area for research and an ideal application of IPM.

Unfortunately, no data were found to form a basis for an IPM option. IPM programs are currently feasible only where there is sufficient knowledge of those parameters involved and when it is possible to exercise control over the parameters. A knowledge of all relevant factors within the ecosystem is mandatory to assure not only the intended results but to preclude any adverse, unintended results. Such information has not been developed for the situations in which strychnine is used. Most IPM work to date has been confined to insect control on specific crops.

The control of mammals and birds on larger areas using IPM techniques is a matter for further research. Range management techniques are being investigated by the Agency and, when available, will be evaluated. Implementation of an IPM program presents further problems. For example, even if a program is of demonstrated feasibility its use cannot be mandated, only stimulated through the elimination or restriction of conventional alternatives.

Therefore, the Agency does not believe that IPM is a feasible option for reducing the risks associated with the use of strychnine at this time. It will, therefore, not be considered for this use, ground squirrels on rangeland, or the others under investigation in this document. The other four measures will be developed under this use and the discussions will be applicable, when noted, for the other site/pest uses.

o Reduction of active ingredient concentrations -

The registered labels of strychnine specify a range of concentrations and use instructions for the various site/pest combinations. On the theory that such formulations are designed to be cost-effective, all of the labels except the one with the lowest concentration/dosage combination would appear to contain more strychnine than necessary.

Risks to nontargets from strychnine bait could then be reduced without reducing benefits by standardizing all labels to conform to the one with the least amount of poison per application. For the control of ground squirrels on rangeland, the bait would have an active ingredient concentration of 0.20 percent and a dosage of one level tablespoon to cover one-two square feet, as per accession number 11150-08490, for Riverside County, California.

o Standardization of baiting and post-baiting procedures -

As with the previous risk reduction method, the Agency is assuming a lower exposure with no impact on benefits. The procedures were taken from currently registered labels, and the rationale is the same as for the reduction in active ingredient concentrations, i.e. standardization of best current practice.

For the control of ground squirrels on rangeland, the procedures to be followed are:

- do not expose bait where pets, poultry, or livestock are present
- do not place bait in piles
- pick up and burn or bury dead animals

o Use of dyed bait -

The rebuttal analysis discussed the use of dyes in bait as a deterrent to feeding by birds during rodent and lagomorph control operations. From an examination of available data, the conclusion was that some risk reduction from dyed baits would be possible for some species of birds. The data were not sufficient to detail the type or color of the dye, nor to predict the bird species that would be protected. No evidence was presented that argued against the use of dyes either due to a reduction in efficacy or to being an attractant to nontarget species. An unpublished report by Palmateer (1980) suggests that some dyes may reduce acceptance by target species. The increased cost involved with producing dyed baits versus undyed is approximately one cent a pound, an increase of less than 0.5 percent.

The durability of the dye in the environment, the effectiveness of dye as a repellent, the time required for a bird to overcome a reluctance to ingest the dyed bait, and the overall risk reduction effects are all unknown. A requirement that bait used for rodent and lagomorph control be dyed in accordance with recommendations of the Fish and Wildlife Service could reduce the primary and secondary risks to nontarget organisms. The impact on benefits is anticipated to be negligible.

o Prohibition of use in the range of endangered species -

1. Utah prairie dog

A critical habitat has not been determined for this species. An estimated 5,700 members live in a six-county area in South Central Utah. This is apparently the permanent residence of the Utah prairie dog. Thus, use of strychnine in this area for rodent control at any time could endanger its existence. Theoretically, baiting might be done safely during the period of hibernation, but the Agency has no information that would permit it to conclude that all of the bait would deteriorate during the winter period.

Since the range of this species is apparently contained within the six counties of Garfield, Iron, Kane, Piute, Sevier, and Wayne, and since no temporal restrictions are applicable, the only enforceable alternative for the protection of the Utah prairie dog is prohibition of strychnine use within this region. Such a prohibition of use would eliminate the risk to the Utah prairie dog associated with the registered use of strychnine. Since very little use is made of strychnine for rodent control in this region, no impact on benefits would be anticipated.

2. California Condor

A critical habitat has been determined for this species. The estimated population of approximately 30 members inhabits an area in the Central California. Although most ground squirrel control efforts in California utilize compound 1080, almost 100,000 lbs. of strychnine bait are also used. Additionally, over 18,000 lbs. of strychnine bait is used in California for bird control.

The risk to the condor from the use of strychnine is apparently slight. The only major uses of strychnine in the condor's range are for pocket gopher, horned lark, and finch control. The use of strychnine for pocket gopher control is not considered in the RPAR action, and, as discussed in Section III, the risk to the condor from the use of strychnine for the control of birds on cropland is generally low.

The benefits of strychnine would increase if compound 1080 were cancelled for ground squirrel control. The risks to the condor for strychnine could also increase substantially. For the condor, the loss of one member would be excessive, given its population status. Prohibition of use in the range of the condor would eliminate the risks to the condor from the use strychnine and have no impact on benefits.

3. Black-footed Ferret

The risk to the black-footed ferret from prairie dog control was discussed on page 31. The question to be addressed in this part is the action to be taken in the areas where prairie dogs and ground squirrels occupy the same area. As previously mentioned, this question was not addressed by USDI in their report to EPA (Appendix D). The primary problem is with the white-tailed prairie dog, whose populations are sometimes intermixed with those of ground squirrels.

For the states affected, (Wyoming, and to a lesser extent Utah and Colorado) ground squirrel control accounted for 23,115 pounds of strychnine bait in 1977-78. Wyoming, with a majority of the white-tailed prairie dogs, used 11,800 pounds. The total amount of strychnine bait for ground squirrel control for all states in this period was 337,230 pounds.

If the use of strychnine for ground squirrel control were to be prohibited in the range of the prairie dog, fumigants or anticoagulants would have to be used for control. Use of fumigants would eliminate the secondary risk to the ferret, but the potential for such effects from the use of anticoagulants is uncertain. Either would increase ground squirrel control costs.

A lesser action would be prohibition of strychnine use for ground squirrel control within any county where the black-footed ferret has been sighted since 1973, the year of enactment of the Endangered Species Act. The use of strychnine in any area where a ferret has been sighted implies a risk of a prairie dog ingesting the poison and a subsequent risk to the ferret from eating a poisoned prairie dog. This is based on the knowledge that the ferret is closely associated with the prairie dog.

A third alternative would be to prohibit use of strychnine for ground squirrel control within some distance of a prairie dog town. If a town is not definable, the locus would be an active prairie dog burrow.

4. San Joaquin Kit Fox

A critical habitat has not been determined for this species. The current population is located in certain areas in the San Joaquin Valley, portions of which are included in the range of the California ground squirrel.

The current risk to the kit fox from strychnine is not high, since compound 1080 is the primary control method for ground squirrel control in California. Should compound 1080 be cancelled, however, the use of strychnine could increase.

Prohibition of the use of strychnine within the range of the San Joaquin kit fox would eliminate the risk from this pesticide to the kit fox. The current benefit impacts of prohibition are not known but are expected to be negligible.

5. Gray Wolf

A critical habitat has been determined only for that portion of the gray wolf population in Minnesota. The present use of strychnine does not pose a serious threat to the gray wolf, as it is rarely if ever used in its range. USDI did not define a range for this species, but recommended prohibition of strychnine use in known gray wolf areas. This option would apparently have no impact on benefits.

6. Grizzly Bear

Areas in four states, Montana, Wyoming, Idaho, and Washington, have been identified as important grizzly bear habitat. Several National Forests, Indian Reservations, National Parks and Wilderness areas are included in this habitat.

The use of strychnine in the range of the grizzly appears to be very small, if used at all. A prohibition of use of strychnine within known grizzly bear areas would virtually eliminate the risks from the use of strychnine and have no impact on benefits.

7. Aleutian Canada Goose

A critical habitat has not been determined for this species. Its migration route in the fall includes the northwestern California coast and interior California valleys. In early spring, they migrate back to the Aleutian Islands.

While total prohibition of strychnine use in the migratory range does not seem warranted, one of two options would be advisable. These would be to prohibit baiting in its California range or prohibit baiting in its California range only during the months of October through April.

8. Peregrine Falcon

At this time, the only method of reducing the risk to the peregrine falcon from ground squirrel control would appear to be from the dyeing of bait. The optimal time for controlling ground squirrels generally coincides with the period of spring migration, making a temporal or geographical use restriction unfeasible. The risk to peregrines from this use appears to be relatively low, however.

2. Rangeland Rodents - prairie dogs

Option - No Action

With this option, the potential for risks to nontargets, including certain endangered species, would continue unabated. The benefits would be similarly unaffected.

Option - Cancellation

The effect of this option would be an elimination of risks from the use of strychnine for prairie dog control on rangeland and pasture.

Zinc phosphide, the alternative most likely to be used if strychnine is cancelled for this use, is of approximately equal efficacy and cost. The risks to gallinaceous birds (and possibly geese and rabbits) are apparently greater from zinc phosphide than strychnine. Otherwise, zinc phosphide poses little demonstrated hazard to other wildlife species when properly used. Risks of secondary poisoning are also generally essentially eliminated. Of particular importance, the toxic risk to the black-footed ferret is virtually eliminated, since secondary poisoning would no longer be likely. Destruction of the ferret's habitat - prairie dog towns - would still be of concern.

Option - Modification of the Terms and Conditions of Registration

- Reduction of active ingredient concentration (see discussion under "Rangeland Rodents-ground squirrels" on page 80) -

For the control of prairie dogs on rangeland, the bait would have an active ingredient concentration of 0.35 percent and a dosage of two teaspoons per square foot (as per EPA registration number 6704-57).

- o Standardization of baiting and post-baiting procedures -

The discussion under "Rangeland Rodents-ground squirrels" for this method is applicable here also.

- o Use of dyed bait -

The discussion under "Rangeland Rodents-ground squirrels" for this method is applicable here also.

- o Prohibition of use in the range of endangered species -

The discussions under "Rangeland Rodents-ground squirrel" for the gray wolf and the grizzly bear are applicable here. A prohibition of use for prairie dog control within the range of black-footed ferret, however, would amount to a cancellation, since the precise range of the black-footed ferret is not known, but can be assumed to be wherever the prairie dog exists.

3. Rangeland Rodents - other rodents and lagomorphs (kangaroo rats, cotton rats, deer mice, meadow mice, jackrabbits, chipmunks, woodchucks)

Option - No Action

With this option, the potential for risks to nontargets, includiung certain endangered species, would continue unabated. The benefits would be similarly unaffected.

Option - Cancellation

This option would eliminate the risk from the use of strychnine for the control of rodents and lagomorphs on rangeland. Very little strychnine bait is used for this purpose (less than one percent of the total usage), and only the cotton rat, kangaroo rat, and jackrabbit cause enough damage to require regular control. Cancellation would therefore have impacts only on a local level. Alternatives are limited, but zinc phosphide is federally registered for control of cotton rats, deer mice and meadow mice. Gas cartridges are federally registered for woodchucks, and Thiram is federally registered for chipmucks. Cancellation would result in an increase in losses in local situations, particularly from pests for which no federally registered toxic alternatives exist (i.e. jackrabbbits, chipmunks and kangaroo rats).

Option - Modification of the Terms and Conditions of Registration

- o Reduction of active ingredient concentration (see discussion under "Rangeland Rodents-ground squirrels" on page 80) -

For the jackrabbit, the concentration would depend on whether a grain or green bait were used. If a grain bait is used the concentration would be 0.28 percent and the dosage would be one tablespoon (as per accession number 11224-08504 for Tulare County, California). If a green bait is used, the concentration of strychnine would be 0.1% (one ounce on three lbs.) and the dosage would be four to five alfalfa shoots (as per accession number 11198-05260 for Sonoma County, California).

Chipmunk bait would have a concentration of 0.50 percent and a dosage of one pound per 10-15 acres (as per EPA registration number 6704-58).

Meadow mouse and deer mouse bait would have a concentration of 0.20 percent with a dosage of 10-15 lbs/acre (as per accession number 11165-08602 for San Benito County, California).

Woodchuck bait would have a concentration of 0.50 percent and a dosage of one teaspoon (as per EPA registration number 728-74).

Kangaroo rat and cotton rat bait would have a strychnine concentration of 0.16 percent. The dosage would be three-four tablespoons if applied by hand or 1/2-3/4 pound per swath-acre if mechanically applied (both the concentration and dosage are as per accession number 11231-05307 for Ventura County, California).

o Standardization of baiting and post-baiting procedures -

The discussion under "Rangeland Rodents-ground squirrels" for this method is applicable here also.

o Use of dyed bait -

The discussion under "Rangeland Rodents-ground squirrels" for this method is applicable here also.

o Prohibition of use in the range of endangered species -

The discussions under "Rangeland Rodents-ground squirrels" for the Utah prairie dog and San Joaquin kit fox are applicable here also.

1. Masked Bobwhite

No critical habitat has been determined for this species. An attempt is being made to reintroduce masked bobwhites in Arizona. The locations are in two valleys, the Altar Valley in Pima County and the Santa Cruz Valley in Santa Cruiz and Pima Counties. These counties are included in the ranges of the jackrabbit and kangaroo rat. Although there is no evidence of strychnine use in these ranges, the possibility does exist. Also, since efforts are underway to establish a population, any use would be posing an unacceptable risk. No alternative toxicants are available for the jackrabbit and kangaroo rat.

2. Red Wolf

No critical habitat has been determined for this species. The range appears to be limited to three counties in Texas (Chambers, Orange, and Jefferson) and two parishes in Louisiana (Cameron and Calcasieu). These counties are included in the range of the *cotton rat* and possibly the *jackrabbit*. While no known Federal or State control programs occur in the range of the red wolf, some commercial uses may exist. Since the extent would be limited, no impact on benefit would be anticipated and the risk would be eliminated by prohibition of use in it's range. Use of zinc phosphide for controlling cotton rats would reduce risks to the red wolf without affecting benefits.

3. Dusky Seaside Sparrow

The critical habitat has been determined for this species. The sparrow inhabits salt marshes in Florida on Merritt Island and on the mainland near Titusville. The only target organism in this area is the *cotton rat*. Since most of the birds inhabit federally controlled lands, the chance of their encountering strychnine is slight.

Since the areas inhabited are apparently the permanent residence for this bird, no temporal use restrictions are possible. Also, the apparently low probability of use indicates prohibition within the range would not result in any benefit impacts. The relative toxicity of zinc phosphide is not predictable for this species, but its registered use in cotton rat infested areas could increase the risk to this sparrow. Chlorophacinone is registered in Florida for the control of cotton rats and would appear to pose very little risk to this sparrow.

4. Cape Sable Sparrow

A critical habitat has been determined for this species. The sparrow is found only in a few herb and brackish marshes in Southwest Florida. No strychnine use is known to occur in its habitat at this time although it is included in the range of the *cotton rat*. The lack of use indicates a lack of impact on benefits if prohibition is imposed. This habitat appears to be a permanent residence, making anything less than total prohibition in its range ineffective for risk reduction. The relative toxicity of zinc phosphide is not predictable for this species, but its registered use in cotton rat infested areas could increase the risk to this sparrow. Chlorophacinone is registered in Florida for the control of cotton rats and would appear to pose very little risk to this sparrow.

5. Mississippi Sandhill Crane

The range of this non-migratory crane is limited to a small area in Southern Jackson County, Mississippi. This area is within the range of the *cotton rat*. A critical habitat was determined for this species. The present population estimate for this crane is 30 to 50 members.

Any use in the range of this species would be unacceptable due to the small population. Benefit impacts of prohibition would be negligible, but the elimination of risk is critical. The use of zinc phosphide, the only available toxicant, as an alternative may or may not reduce the risks.

6. Attwater's Greater Prairie Chicken

A critical habitat has not been determined for this species. The current population is under 2,000, and is limited to the prairies on the Texas Gulf Coast. This area is included in the ranges of the jackrabbit and the cotton rat. Texas uses less than three percent of the total strychnine used by all the states, virtually all going for the control of ground squirrels and prairie dogs. Thus, the cancellation of strychnine use in the range of the Attwater's greater prairie chicken would have no impact on benefits. Since the present range is the permanent residence of the chicken, no restrictions other than prohibition of use in that range would eliminate the risks from strychnine. Since zinc phosphide formulations are sustantially more toxic to gallinaceous birds than is strychnine, cancellation of strychnine for cotton rat control would increase risks to this prairie chicken.

7. Morro Bay Kangaroo Rat

Approximately 3,000 members of this species exist only in a few square miles on the south side of Morro Bay, San Luis Obispo County, California. Roughly one square mile of private property has been designated as the critical habitat.

With the possible exception of the black-tailed jackrabbit, none of the target rodents inhabit the range of this endangered species. Since no evidence exists that strychnine is being used in the range of the Morro Bay kangaroo rat, however, no impact or benefits should result from prohibition. Also, no restrictions other than prohibition of use in its range would eliminate the potential risk to the species from strychnine. Anticoagulants are registered in California for the control of jackrabbits, and they may or may not reduce the risks to this kangaroo rat.

4. Cropland Rodents - ground squirrels

The available options, and their impacts, are the same as for ground squirrels on rangeland.

5. Cropland Rodents - prairie dogs

The available options, and their impacts, are the same as for prairie dogs on rangeland, with the important distinction that if strychnine were cancelled, the only federally registered alternative is gas cartridges. This increases the costs of control, but reduces the risk to nontarget species, especially the black-footed ferret.

6. Cropland Rodents - other rodents and lagomorphs

The available options, and their impacts, are the same as for other rodents and lagomorphs on rangeland, with the exception that no federally registered alternatives are available for the control of cotton rats and kangaroo rats. Gas cartridgesare federally registered for use on woodchucks; repellants are federally registered for jackrabbits, and anticoagulants are available for meadow mice and deer mice.

7. Rodents and Lagomorphs on Nonagricultural Sites

Option - No Action

With this option, the potential for risks to nontarget species, including certain endangered species, would continue unabated. The benefits would be similarly unaffected.

Option - Cancellation

Cancellation of strychnine uses to control rodents and lagomorphs on nonagricultural sites would eliminate the risks from strychnine to non-target organisms. Some benefits are realized from this use, particularly for canals and levees, but alternatives are available for the primary pest, the ground squirrel. Alternatives most likely to be used, fumigants, are not without risks. The risks are less than those for strychnine, however, and secondary risks would be eliminated. Federally registered alternatives are not available for the porcupine, jackrabbit, kangaroo rat, chipmunk, opossum and mountain beaver.

Option - Modification of the Terms and Conditions of Registration

o Reduction of active ingredient concentration -

The discussion under the rangeland uses for this method are applicable here also.

o Standardization of baiting and post-baiting procedures -

The discussion under "Rangeland Rodents-ground squirrels" for this method is applicable here also.

o Use of dyed bait -

The discussion under "Rangeland Rodents-ground squirrels" for this method is applicable here also.

o Prohibition in the range of endangered species -

The discussion for all species under rangeland uses are applicable here also. In addition, the salt marsh harvest mouse should be considered. No critical habitat has been determined for this species. The range is apparently confined to certain salt marshes and adjoining habitats around San Francisco Bay. No known strychnine uses occur within this range. The prohibition of use within the range should eliminate any potential risks and have no impact on benefits.

8. Birds on Cropland

Option - No Action

With this option, the potential for risks to nontarget organisms would continue unabated. No endangered species are known to be at substantial risk from these uses of strychnine. Benefits would be similarly unaffected.

Option - Cancellation

This cancellation would apply to the current state registrations in California, Nevada, and Wyoming, since strychnine is not federally registered for these uses. Since no alternative toxicants are available, cancellation could result in an increase in crop damage. The available alternatives are primary repellants or frightening agents and may or may not be as effective as strychnine, but comparisons with a toxicant are not possible.

The risks to nontarget species from strychnine would be eliminated, and, since no alternative toxicants are available, the use of substitutes would present less risks than strychnine.

Option - Modification of the Terms and Conditions of Registration

- Reduction of active ingredient concentration -

As with the uses of strychnine to control mammals, the registered lables for strychine bait used for the control of birds specify a range of concentrations. The concentrations differ not only for different birds, but also for each bird. For the available LD_{50} data for passerines, a reasonable assumption is that one concentration, namely the lowest one currently registered, should be appropriate for all bird control operations on cropland. The concentration would thus be 0.20 percent (as per accession number 11019-09355 for blackbirds in Fresno County, California).

- Standardization of baiting and post-baiting procedures - (See the discussion under "Rangeland Rodents-ground squirrels" on page 80.)

For the control of birds in orchards and vineyards, the procedures to be followed are:

- bait must be placed in troughs no less than three inches deep (v-shaped with ends blocked to avoid spillage).
- troughs must be made removable so that they can be cleaned out after each change of bait.
- troughs must be at least four feet from ground level
- placement of troughs must be made near the edge of the affected field near the areas where the birds perch and rest, not directly under these perching places. Placement of troughs inside the fields must be avoided.
- Expose poisoned bait sparingly - one inch deep in each trough
- pick up all remaining bait at end of day; burn any bait spillage.
- pick up and bury or burn of all dead birds at the end of each day

For the control of horned larks on crops the procedures to be followed are:

- expose bait sparsely in a depression between bedded crops
- pick up remaining bait at the end of day, burn any bait spillage
- pick up and bury or burn all dead birds at the end of the day

9. Birds - on Nonagricultural Sites

Option - No Action

With this option, the potential for risks to nontarget organisms, and particularly to the peregrine falcon, would continue unabated. The benefits would be similarly unaffected.

Option - Cancellation

The impact on benefits from this option would apparently be limited to the elimination of a fast-acting control of pigeons in the case of a possible local public health issue. Alternatives are available, but they do not provide this benefit.

The risks from the use of strychnine would be eliminated, and the alternatives, with the possible exception of starlicide (registered in California only), do not present toxic risks equal to strychnine. In particular, the risks to the peregrine falcon from the use of strychnine for pigeon control would be eliminated.

Option - Modification of the Terms and Conditions of Registration

- Reduction of active ingredient concentration -
(See the discussion under "Birds on Cropland" on page 90.)

For the control of pigeons on nonagricultural sites, the bait would have a strychnine concentration of 0.6 percent as per all current federally registered labels.

For the control of house sparrows on nonagricultural sites, the bait would have a strychnine concentration at 0.25 percent (as per accession number 11198-05259 for Sanoma County, California).

- Standardization of baiting and post-baiting procedures -
(See the discussions under "Rangeland Rodents-ground squirrels".)
    - pick up and burn or bury any uneaten bait
    - where uneaten bait is not easily retrievable, place bait in trays or v-shaped troughs
    - pick up and bury or burn all dead birds daily

- Prohibition of use in the range of endangered species -

1. Puerto Rican Plain Pigeon

A critical habitat has not been determined for this species. Its range is confined to a relatively small area in east central Puerto Rico in and around the municipalities of Cidra, Camerio, Aguas Buenas, Caguas, and Cayey.

No information is available on the use of strychnine in Puerto Rico, but it is assumed to be negligible. No methods are available to eliminate the risk to the pigeon, should strychnine be used, since the range described is its permanent residence. Prohibition of use would apparently have no impact on benefits. The only potential use would be for the control of pigeons, and federally registered alternatives are available.

2. Yellow-shouldered Blackbird

A critical habitat has been determined for this species. The bird is concentrated in three areas in Puerto Rico, coastal Southwestern Puerto Rico, coastal Northeastern Puerto Rico, and Mona Island. As with the Puerto Rican plane pigeon, the extent of strychnine use in the area of the blackbird is not known, but is assumed to be insignificant. Thus, no impact on benefits is anticipated from any action taken. The only option for eliminating risks would be prohibition of use. The only potential use would be for the control of pigeons, and federally registered alternatives are available.

3. Peregrine Falcon

The potential for risk to the peregrine falcon from secondary poisoning is of particular concern during strychnine baiting for pigeon control. The Arctic peregrine's migration route could bring it through any of the lower 48 States. The American peregrine breeds west of the Mississippi River, but its migratory patterns are not well documented.

The potential for peregrine falcons to be exposed to strychnine during pigeon control operations varies geographically. In the eastern part of the country, the urban location of falcons that have been established as a result of the restoration program are generally well known. The risks can thus be greatly reduced by prohibition of use of strychnine for pigeon control within a five mile radius of aeries.

In the Rocky Mountain Region, most potential exposure to peregrines from pigeon control is to falcons that winter in or near urban areas. A prohibition of use for pigeon control during the winter months would therefore greatly reduce the risk to the falcon.

In California, a critical habitat has been established for the peregrine falcon. Adults are apparently permanent residents in California, Oregon, and Washington. A prohibition of use for pigeon control within a five mile radius of the critical habitat would greatly reduce the risk to the peregrine falcons.

Prohibition of use for pigeon control nationwide from mid-March through April and, from mid-September through October would protect most Arctic migrants.

D. Proposed Action

1. Rangeland Rodents - ground squirrel

The Agency proposes adoption of the modification of the terms and conditions option. The lack of alternatives, the potential impact on benefits, and the potential for risk reduction, particularly to endangered species, are the major factors in this proposed action. With certain risk reduction measures, the Agency concludes that the benefits will outweigh the risks.

For this use, then, the Agency proposes the following modifications:

a. Standardize bait concentrations of 0.20 percent active ingredient, and a dosage of one level tablespoon/burrow

b. Standardize baiting and post-baiting procedures to read:

- do not expose bait where pets, poultry, or livestock are present
- do not place bait in piles
- pick up and burn or bury all dead animals

c. Use bait dyed in accordance with recommendations of the Fish and Wildlife Service

d. Prohibit use for the protection of endangered species as follows:

species	prohibited area
Utah prairie dog	Garfield, Iron, Kane, Piute, Sevier, and Wayne Counties, Utah
California condor	Fresno, Kern, Kings, Los Angeles, Merced, Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Clara, Santa Cruz, Stanislaus, Tulare, and Ventura counties, California
Black-footed ferret	within one mile of a prairie dog town or an active prairie dog burrow
San Joaquin kit fox	Alameda, Contra Costa, Fresno, Kern, Kings, Merced, Monterey, San Benito, San Joaquin, San Luis Obispo, Santa Barbara, Santa Clara, Stanislaus, and Tulare counties, California
Gray wolf	known gray wolf areas
Grizzly bear	known grizzly bear areas
Aleutian Canada goose	Butte, Colusa, Contra Costa, Del Norte, Glen, Humboldt, Mendocino, Merced, San Joaquin, Solano, Stanislaus, Sutter, Yolo, and Yuba counties, California during the months from October through March.

Additionally, for the general protection of all endangered species, the following will be included on all labels:

> "This product must not be used in areas where adverse impact on federally designated endangered or threatened species is likely. Prior to making applications of this product, the user must determine that such species are not located in or immediately adjacent to the area to be treated. Consult your Regional U.S. Fish and Wildlife

Service Office (Endangered Species Specialist) or the local Fish and Game Office for specific information on endangered species."

2. Rangeland Rodents - prairie dogs

The Agency proposes adoption of the cancellation of use option. The inability to reduce the risk to the black-footed ferret and the availability of zinc phosphide are the major factors in this proposed action. The Agency concludes that the risks of using strychnine to control prairie dogs outweigh the benefits, and that no risk reduction measures are available to change the situation.

3. Rangeland Rodents - other rodents and lagomorphs

For deer mice, meadow mice, chipmunks and woodchucks, the Agency proposes the cancellation of use option. The use of strychnine for these uses presents a risk to non-target species. The benefits of the use of strychnine for these pests is very low, chemical alternatives are available for all four mammals.

For the cotton rat, kangaroo rat, and jackrabbit, the Agency proposes the modification of terms and conditions option. The lack of specific risk information, and the potential for reducing risks without impacting benefits are the major factors in this proposed action.

The Agency concludes that, with certain risk reduction measures, the benefits of using strychnine for this use will outweigh the risks.

For these uses, then, the Agency proposes the following modifications:

a. Standardize bait concentrations at:

   for the jackrabbit, 0.28 percent with a dosage of one tablespoon for grain bait or 0.1 percent with a dosage of four-five alfalfa shoots for green bait; for the kangaroo rat and the cotton rat, 0.16 percent with a dosage of three-four tablespoons for hand application or 1/2-3/4 pound per swath-acre for mechanical application.

b. Standardization of baiting and post-baiting procedures as per the proposal for "Rangeland Rodents - ground squirrels."

c. Use bait dye in accordance with recommendations of the Fish and Wildlife Service.

d. Prohibit use, for the protection of endangered species, as follows:

species	use	prohibited area
Utah prairie dog	kangaroo rat jackrabbit	See "Rangeland Rodents-ground squirrel"
San Joaquin kit fox	jackrabbit kangaroo rat	See "Rangeland Rodents-ground squirrels"
Masked bobwhite	jackrabbit kangaroo rat	Pima and Santa Cruz counties, Arizona
Red wolf	jackrabbit cotton rat	Chambers, Orange, and Jefferson counties, Texas; Cameron and Calcasieu Parishes, Louisiana
Dusky seaside sparrow	cotton rat	Brevard county, Florida
Cape Sable sparrow	cotton rat	Collier, Dade, and Monroe counties, Florida
Mississippi sandhill crane	cotton rat	Jackson county, Mississippi
Attwater's greater prairie chicken	jackrabbit	Aransas, Austin, Brazoria, Calhoun, Chambers, Colorado, DeWitt, Fort Bend, Galveston, Goliad, Harris, Jackson, Jefferson, Lavaca, Matogorda, Refugio, Victoria, Waller, and Wharton counties, Texas
Morro Bay kangaroo rat	jackrabbit	San Luis Obispo county, California

Additionally, for the protection of all endangered species, the same wording for labels proposed for the control of ground squirrels on rangeland will be applicable here also.

4. Cropland Rodents - ground squirrels

The proposed action for this use is the same as for ground squirrels on rangeland, i.e., modification of the terms and conditions of registration.

5. Cropland Rodents - prairie dogs

The proposed action for this use is the same as for prairie dogs on rangeland, i.e. cancellation.

6. Cropland Rodents - other rodents and lagomorphs

The proposed action for this use is the same as for other rodents and lagomorphs on rangeland, i.e. cancellation for use to control deer mice, meadow mice, woodchucks and chipmunks, and modification of the terms and conditions of registration for use to control cotton rats, kangaroo rats, and jackrabbits.

7. Rodents and Lagomorphs on Nonagricultural Sites

The only uses under this category for which the Agency concludes that the benefits will outweigh the risks, with modifications of the terms and conditions of registration, are ground squirrels on ditch banks, levees, canals, and earthen dams, and porcupines in tree nursuries, tree plantations, and reforestation areas (forests). For all other site/pest uses under this category, the Agency proposes cancellation.

For rodents and lagomorphs on nonagricultural sites, the Agency proposes the following actions:

pests	sites	action
rabbits and jackrabbits, chipmunks, marmots/ woodchucks, prairie dogs, kangaroo rats, cotton rats, meadow mice, marmots, mountain beavers, opossums	grain elevators, crop storage areas and facilities, commercial open dumps, farmsteads, urban dwellings, ditch banks, levees, dikes, canals, earthen dams, golf courses, parks, cemetaries, airport turf runways, military bases, forests, reforestation areas, tree plantations and similar nonagricultural sites	cancel
ground squirrels	ditch banks, levees, canals, earthen dams	modification of the terms and conditions of registration
porcupines	forests, reforestation areas, tree plantations	modification of the terms and conditions of registration

For the control of ground squirrels, the use modifications will be identical to those proposed for the control of ground squirrels on rangeland. For the control of porcupines, the following modifications are proposed:

- standardization of bait concentration at 5.8 percent in salt blocks
- nail salt block at least ten feet above the ground
- do not use in known gray wolf or grizzly bear areas

Additionally, for the protection of all endangered species, the same wording for labels proposed for control of ground squirrels on rangeland will be applicable here also.

8. Birds on Cropland

The Agency proposes the adoption of the modification of terms and conditions options. The lack of specific risks to nontarget organisms, the apparent low risks to endangered species, the absence of comparative data on alternatives, and the potential for local impact on benefits were the major factors in this proposed action.

With certain risk reduction measures, the Agency concludes that the benefits will outweigh the risks.

For these uses, then, the Agency proposes the following modifications:

a. standardize bait concentrations at 0.20 percent active ingredient

b. standardize baiting and post-baiting procedures to read:

For the control of birds in orchards and vineyards:

- bait must be placed in troughs no less than three inches deep (v-shaped with ends blocked to avoid spillage)
- troughs must be made removable so that they can be cleaned out after each change of bait
- troughs must be at least four feet from ground level
- placement of troughs must be made near the edge of the affected field near the areas where the birds perch and rest, not directly under these perching places. Placement of troughs inside the fields must be avoided
- expose poisoned bait sparingly - one inch deep in each trough
- pick up all remaining bait at end of day; burn any bait spillage

- pick up and burn or bury all dead birds at the end of each day

For the control of horned larks on crops:

- expose bait sparsely in a depression between bedded crops
- pick up remaining bait at the end of day, burn any bait spillage
- pick up and burn or bury all dead birds at the end of the day

Additionally, for the protection of all endangered species, the same wording for labels proposed for control of ground squirrels on rangeland will be applicable here also.

9. Birds on Nonagricultural Sites

The Agency proposes the adoption of the modification of the terms and conditions option. The lack of specific risk information (with the exception of the risk to the peregrine falcon), the potential for eliminating the risk to the falcon, and the benefits of potential disease control, were the major factors in this proposed action. With certain risk reduction measures, the Agency concludes that the benefits outweigh the risks.

For these uses, then, the Agency proposes the following modifications:

a. standardize pigeon bait concentrations at 0.6 percent active ingredient

b. standardize house sparrow bait concentrations at 0.25 percent active ingredient

c. standardize baiting and post-baiting procedures to read:

    - pick up and burn all uneaten bait at the end of each day
    - where uneaten bait is not easily retrievable, place bait in trays or v-shaped troughs
    - pick up and burn or bury all dead birds daily

d. prohibit use for the protection of endangered species as follows:

species	prohibited area
Yellow-shouldered blackbird	Puerto Rico
Puerto Rican Plain Pigeon	Puerto Rico

species	prohibited area (Continued)
Peregrine falcon (pigeon control only)	In the Eastern U.S: prohibit use within five miles of aeries In the Rocky Mountain Region: prohibit use from November through March In California, Oregon, and Washington prohibit use within five miles of critical habitats. 48 contiguous states: prohibit use during the months from mid-September through October and mid-March through April.

Additionally, for the protection of all endangered species, the same wording for labels proposed for control of ground squirrels on rangeland will be applicable here also.

E. Summary

For each use of strychnine to control a pest on an outdoor, above-ground site, the Agency has proposed either cancellation of use, or a modification of the terms and conditions of registration. This section summarizes those proposed actions.

For rangeland and pasture uses, the proposed action for each pest is:

ground squirrels - modification of the terms and conditions of registration

prairie dogs - cancellation

deer mice - cancellation

meadow mice - cancellation

chipmunks - cancellation

marmots/woodchucks - cancellation

cotton rats - modification of the terms and conditions of registration

kangaroo rats - modification of the terms and conditions of registration

jackrabbits - modification of the terms and conditions of registration

For cropland uses, the proposed activity for each pest is:

ground squirrels - modification of the terms and conditions of registration

prairie dogs - cancellation

deer mice - cancellation

meadow mice - cancellation

chipmunks - cancellation

marmots/woodchucks - cancellation

cotton rats - modification of the terms and conditions of registration

kangaroo rats - modification of the terms and conditions of registration

jackrabbits - modification of the terms and conditions of registration

birds - modifications of the terms and conditions of registration

For nonagricultural site uses, the proposed action for each pest is:

jackrabbits - cancellation

chipmunks - cancellation

marmots/woodchucks - cancellation

prairie dogs - cancellation

kangaroo rats - cancellation

cotton rats - cancellation

deer mice - cancellation

meadow mice - cancellation

mountain beavers - cancellation

opossums - cancellation

rabbits - cancellation

ground squirrels - modification of the terms and conditions of registration

porcupines - modification of the terms and conditions of registration

pigeons - modification of the terms and conditions of registration

house sparrows - modification of the terms and conditions of registration

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